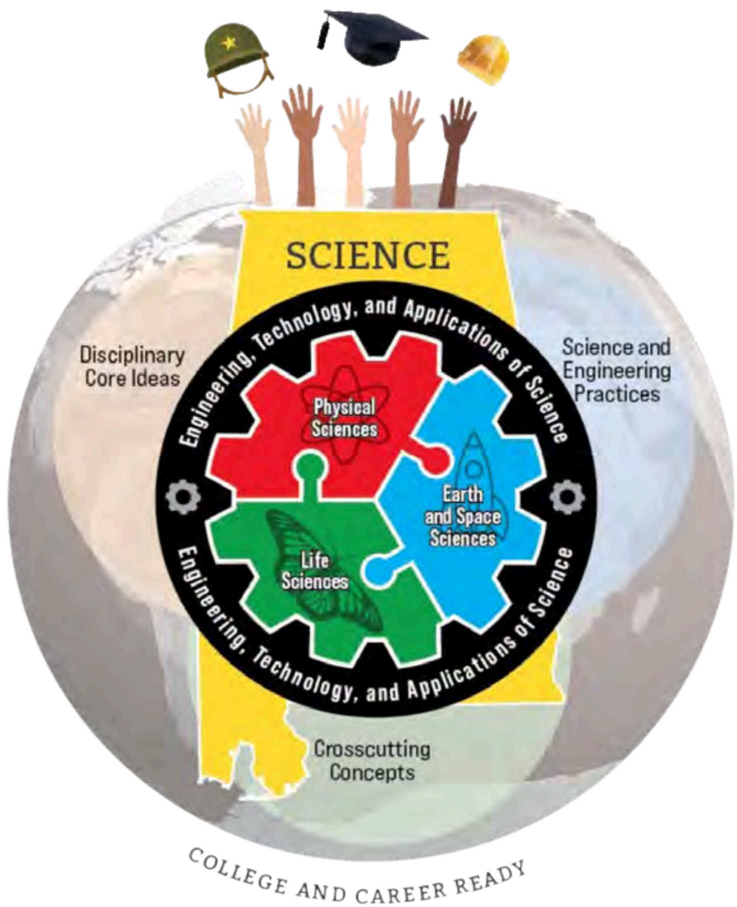
Alabama Course of Study: Science



2023

Eric G. Mackey, State Superintendent of Education

Alabama State Department of Education

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Alabama Course of Study: Science

Eric G. Mackey
State Superintendent of Education

STATE SUPERINTENDENT OF EDUCATION'S MESSAGE

Dear Alabama Educator:

To be truly educated, students need to understand the world around them, which is an underlying goal of science education. In addition, society and the workplace require that all Alabama students receive a solid foundation of knowledge, skill, and understanding in science

To meet these goals, educators must adhere to the guiding philosophy of "Every Child. Every Chance. Every Day" to ensure that children in Alabama's public schools become productive, responsible citizens. Alabama teachers must focus on teaching science as a way of *doing* as well as *knowing*, utilizing science and engineering practices in their classrooms. The standards in the 2023 *Alabama Course of Study: Science* are written to support equitable, innovative, and creative learning.

Implementing these standards through appropriate instruction will enable Alabama students to become well-informed citizens who can appreciate the beauty and wonder of science and the natural world, engage in discussions on the issues of the day, utilize science and technology in their daily lives, and develop the skills that allow them to enter the careers of their choice.

Eric G. Mackey
Superintendent of Education

Alabama Course of Study: Science

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PREFACE

The 2023 *Alabama Course of Study: Science* provides the framework for the study of science in grades Kindergarten through twelve in Alabama's public schools. Content standards in this document are minimum and required (*Code of Alabama*, 1975, §16-35-4), fundamental and specific, but not exhaustive. Local school systems may create additional content standards to reflect local philosophies which may include implementation guidelines, resources, and activities that enhance scientific concepts and phenomena. The course of study provides the foundation on which local education agencies may build a robust learning sequence.

The 2023 *Alabama Course of Study: Science* consists of clearly defined standards reflecting the vision of the National Research Council's 2012 publication, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* The course of study's revised organization and format better support educators' comprehension of three dimensional learning in science.

In addition to the 2012 National Research Council framework, the committee reviewed the 2015 *Alabama Course of Study: Science*, standards from other states, articles in professional journals and magazines, and national evaluations of state standards. Members reviewed suggestions from interested individuals and groups throughout Alabama, used each member's academic and experiential knowledge, and thoroughly discussed each issue and standard among themselves. As a result, this document represents the scientific knowledge and practices necessary to provide graduates with scientific and engineering literacy for success in college, career, and citizenship. The committee and task force reached consensus and believe that their work has resulted in the best possible science course of study for Alabama's students.

Alabama Course of Study: Science
ACKNOWLEDGMENTS

This document was developed by the 2023 Alabama State Science Committee and Task Force, composed of Grades K-12 and college educators appointed by the Alabama State Board of Education and business and professional persons appointed by the Governor (*Code of Alabama*, 1975, §16-35-1). The Committee and Task Force began work in January of 2023 and submitted the document to the Alabama State Board of Education for adoption at its December 2023 meeting.

Science Course of Study
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Alabama Course of Study: Science

GENERAL INTRODUCTION

The *Alabama Course of Study: Science* defines what learners should know and be able to accomplish after each grade level or course in order to be scientifically literate citizens upon graduation.

This document was created by the Science Course of Study Committee and Task Force consisting of educators from kindergarten through college, education specialists, public school administrators, and business and community leaders. Teachers with expertise in special populations were present with the committee and task force to offer advice, perspective, and professional expertise as the group considered the supports which are needed for students with special needs.

The structure of the Alabama course of study in science reflects the approach outlined by the National Research Council's 2012 document, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* The 2023 *Alabama Course of Study: Science* incorporates the three dimensions around which K-12 science and engineering education are built. These dimensions are scientific and engineering practices, crosscutting concepts that unify the study of science through their common application across all domains of science and engineering, and the disciplinary core ideas in the physical, life, and Earth and space sciences and in engineering, technology, and applications of science.

Alabama's K-12 science program emphasizes the importance of teaching science every day to every student in every grade. This document provides foundational knowledge and learning progressions that are coherent, vertically aligned, and increasingly rigorous. The standards are designed to prepare scientifically literate citizens who can evaluate the quality of science information, appreciate science as a way of knowing about the world, and make sound, evidence-based decisions. Effective implementation of the 2023 *Alabama Course of Study: Science* will help develop confident and capable graduates who are vital to Alabama's economic productivity and our nation's competitiveness in the global market.

All standards contained in this document are

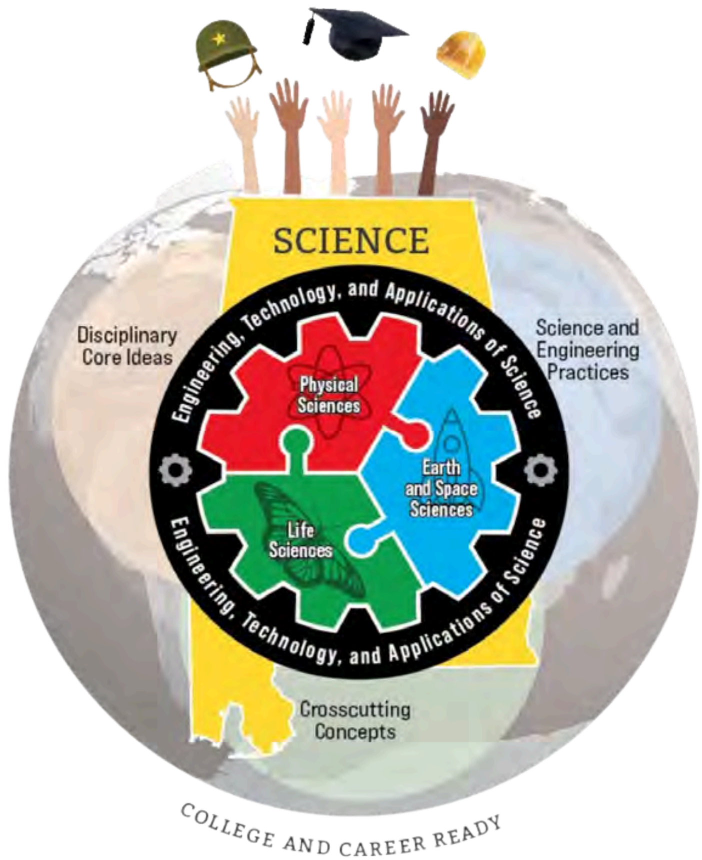
- written in a clear, understandable, and consistent format to be relatable and applicable to learners' lives;
- organized in ways that are appropriate for their particular grade band;
- designed to include rigorous, focused, critical content and application of knowledge through high-order skills;
- grounded on sound, evidence-based research; and
- designed to prepare all students to succeed in our global economy and society.

Effective implementation of the 2023 *Alabama Course of Study: Science* requires local education agencies to research and adopt curriculum addressing the minimum required content found in this document. Local systems may add standards, but no standards may be omitted. Systems should also adopt implementation guides, resources, and activities which not only fulfill the requirements of the standards but also provide opportunities to go beyond them.

Professional learning is required to ensure that teachers become familiar with the standards, dimensions, structure, and organization of the 2023 *Alabama Course of Study: Science*. Familiarity with the document will aid in the selection of curricular materials and with planning for effective instruction.

Alabama Course of Study: Science

CONCEPTUAL FRAMEWORK



CONCEPTUAL FRAMEWORK

The conceptual framework on the preceding page is a graphic representation of the goals and structure of the 2023 *Alabama Course of Study: Science.* The course of study is designed to present standards and progressions which will produce scientifically literate citizens who are fully prepared for college and careers. Scientifically literate citizens have a foundation of scientific knowledge, a technological understanding of problem-solving, and an innovative ability to design scientific solutions. The framework illustrates the correlation among these aspects of scientific literacy by highlighting the three basic dimensions of their development: science and engineering practices, crosscutting concepts, and disciplinary core ideas, which together form the foundation of every content standard.

The hats at the top represent a variety of the college or career paths that scientifically literate Alabama students can pursue. The hands below them represent students taking the knowledge they have gained into their future endeavors. The cog represents the connectivity and movement provided for essential science concepts by scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. The interlocking puzzle pieces show that the domains are interconnected. The image of the state of Alabama is dominant in the design, emphasizing the state as a leader in science. All Alabama students should be provided every opportunity to achieve scientific and engineering literacy from a global perspective, as indicated by the image of Earth.

The domains of science are superimposed on the graphic of the state of Alabama. Earth and space sciences domain is represented by a rocket, the image of an atom characterizes the physical sciences, and the monarch butterfly (state insect) symbolizes the life sciences domain. The cog is surrounded by a border featuring the engineering, technology, and applications of science domain, which emphasizes engineering design. Emphasis on the domains begins in kindergarten and continues through high school, with concepts increasing in depth and rigor as students focus on deeper understanding and application of content.

POSITION STATEMENTS

The 2023 *Alabama Course of Study: Science* defines the minimum content in terms of what students should know and be able to do at the end of each course or grade, using the three dimensions indicated in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (*National Research Council, 2012). Educators and leaders at school and district levels must engage with the standards and systematically apply them to create excellent science education programs that meet the needs of their students.

Certain fundamental understandings are integral to educators' understanding and application of the course of study. The committee and task force has formulated position statements to elaborate upon the expectations under which local education agencies should work as they select and write curriculum and other materials to implement the course of study.

1. Science classrooms in Alabama must create opportunities for students to develop scientific literacy.

Well-prepared graduates are expected to be scientifically literate. A scientifically literate person understands what science is and how to use it to make decisions and take actions in everyday life. Scientifically literate persons can access and evaluate information so that they can understand scientific concepts and phenomena and apply this knowledge to new and often nonscientific situations. They can identify credible sources and evaluate their reliability, which can combat the propagation of misinformation and misconceptions. Engagement in research and engineering is essential for the development of scientific literacy training.

To achieve scientific literacy, students must use reading, writing, speaking, and listening to access, process, and communicate scientific knowledge. All students, K-12, are expected to use developmentally-appropriate literacy skills in the science classroom, such as reading scientific texts; writing observations and data, journaling, and composing reports or essays; and communicating their ideas using current technology for presentations and discussions. These skills are further defined in standards in Alabama's English Language Arts and digital literacy and computer science courses of study. Improving students' general literacy through science instruction goes hand in hand with fostering scientific literacy.

2. Students must develop an understanding of the nature of science in order to become scientifically literate.

The nature of science is an integral component of instruction, beginning in the earliest grades. While the rigor of concepts and skills progresses throughout a student's education, the core principles of science remain constant. For students to become scientifically literate, the nature of science must be explicitly addressed through instruction (alongside scientific and engineering practices, disciplinary core ideas, and crosscutting concepts) and through reflective discussions among students about the science concepts they are learning.

Throughout history, humans have attempted to explain the natural world in which they live, and current scientific knowledge and engineering practices are the results of humankind's ongoing quest to answer questions about natural phenomena. While there is no single pathway to discovering new scientific knowledge, the scientific community agrees on these foundational principles about the nature of science.

- Science is a human endeavor that is historically and culturally embedded in society.
- Science uses data to understand and explain phenomena in the natural world.
- Science assumes that order, consistency, and mathematically interpreted patterns exist in natural systems.
- Scientific knowledge and theory are based on empirical evidence and are open to revision in light of new evidence.
- Science attempts to avoid bias and demands that knowledge, information, and discoveries be shared for review by others around the world.
- Science requires creativity and imagination for the proposal of hypotheses and solutions, while simultaneously requiring logical reasoning to test and validate hypotheses and solutions.
- Scientists utilize a variety of methods for investigation; while there are common aspects of inquiry, there is no universal scientific method.

3. All students should have opportunities to learn scientific information through inquiry and experience, using their individual funds of knowledge to enhance classroom instruction.

Science and engineering are collaborative processes that take place within a global scientific community. Throughout history, individuals and groups of people from many backgrounds and societies have contributed to the body of scientific knowledge. This knowledge has resulted in remarkable technological advances that benefit all humankind. The future scientific community can be enhanced by having many perspectives represented. To enhance the growth of scientific knowledge, all students should have equal access to learning science.

Scientific learning is built on the foundation of students' funds of knowledge, which are derived from family and community cultural practices and bodies of knowledge. Valuing students' individual funds of knowledge enhances teaching and learning in the science classroom. Educators should actively encourage students to share their science-related experiences in positive ways to promote sharing and collaboration in learning.

Educators should also utilize instructional strategies that recognize and respect the differences that students bring to the classroom. Schools should provide access to quality learning space and equipment, qualified teachers who are enthusiastic about science, and adequate time for instruction and practice.

4. Providing differentiated instruction in the science classroom is essential for meeting the diverse needs of all students.

Differentiated instruction must be implemented in the science classroom in order to achieve the goal of access and equity for all students. For many students, including English learners, students with exceptionalities, and those in need of AL-MTSS (Alabama Multi-Tier System of Supports), differentiated instruction is crucial for academic success.

- **Teachers of English Learner (EL) students need to understand and integrate content, language, and pedagogy in order to provide high-quality science instruction.**
  Integrating language learning with science content provides necessary scaffolds and ensures that science teaching practices and materials are both inclusive and culturally relevant. English learners who simultaneously engage with science content and develop their language skills show greater academic success.

  The Alabama English Language Learners (ELL) Framework supports educators in shifting from traditional to systemic practices. These practices can include differentiated instruction, instructional strategies, and accommodations to ensure meaningful access to science content, bridge linguistic gaps, and address the individual needs of every student. The National Science Teaching Association (NSTA, 2023) recommends strategies that are gestural, oral, pictorial, graphic, and textual, which will ultimately benefit all learners. Teachers should regard native languages and cultures as assets to be embraced, not barriers to be circumvented.

  Every student is given opportunities to interpret scientific explanations using data and evidence gathered from models, simulations, and hands-on activities. Just like their peers, English Learners possess unique perspectives, eagerness to inquire, and capacity to uncover both new and familiar information. These characteristics may serve as the entry point and driving force for equitable access to high-quality, rigorous instruction tailored to students' linguistic needs.

- **Collaboration between general education and special education teachers is essential for determining and meeting individual students' needs**.
  Collaboration creates opportunities for special education students to master science content using accommodations that allow them to learn more effectively, rather than implementing modifications which change content expectations. Working collaboratively, teachers can determine how to incorporate technology and instructional strategies that will implement the specific goals mandated in students' IEPs, 504 Plans, and other applicable educational plans.

- **The AL-MTSS (Alabama Multi-Tier System of Supports) framework should be utilized in the science classroom to ensure student success.**
  Alabama's Multi-Tier Systems of Support (AL-MTSS) involves all members of school campuses in the mission of embracing a proactive approach to ensuring a quality education designed to expand each learner's potential. AL-MTSS stresses the importance of focusing on the whole child and paying attention to the academic, behavioral, and foundational wellness needs of students. To meet these needs, science teachers must, at minimum, foster social skills by allowing students to interact with one another.

  Science teachers will need to differentiate instructional strategies, provide ongoing formal and informal assessments, and collaborate within their school communities to provide experiences for learners. Teachers will monitor student progress in order to identify those who need targeted and intensive interventions and work within the AL-MTSS framework to determine which interventions are appropriate. Using the available resources, teachers should implement the interventions to promote student success.

5. High-quality teaching and learning in science require a collaborative classroom environment, an instructional design that promotes exploration, a variety of assessments, and opportunities to make cross-curricular connections.

Quality science instruction can look very different from classroom to classroom yet still achieve the goal of developing scientifically literate students. However, there are many common facets that must be considered in designing appropriate science classroom instruction:

Student characteristics
- Curiosity - Children are born investigators. Teachers should tap into students' natural curiosity to foster their interest in science at all ages. This is especially vital in the early years, where it provides foundational knowledge for future learning.
- Building on student interest and identity - Learning in science depends not only on the accumulation of facts and concepts but also on the development of an identity as a competent learner of science with motivation and interest to learn more. This should be a consideration when designing lessons (National Research Council, 2012).

Instruction
- Classroom environment - The science classroom should be collaborative, student-centered, and connected to the real world for students to be actively engaged learners. The classroom should provide opportunities for creative scientific exploration and engineering design, active learning, immersion in scientific practices, use of critical thinking, and investigative processes.

- Instructional design - Planning for instruction should include: (1) identifying the outcome from the standards, (2) determining acceptable evidence of student learning, and (3) developing engaging activities and learning experiences based on the desired outcome. Activities can be planned using a variety of models, such as phenomenon-based instruction or the 5E + IA Model (Zuiker and Whitaker, 2013).
- Phenomenon-based instruction - This instructional practice, which is highly recommended by the NRC Framework, begins with capturing the students' interest with phenomena which they then investigate to discover and build knowledge. It is important to use phenomena which are relevant to their lives and experiences so that students' engagement is maximized and prior knowledge can be used as a foundation.
- Assessment - Assessment should be aligned with standards and curriculum, provide opportunities for students to demonstrate what they know and what they can do, cover all three dimensions of the content standards (DCI, SEP, CCC), and utilize both formative and summative methods. Teachers should use feedback from assessments to decide when to accelerate, enrich, and intervene in instruction.
- Laboratory investigations - Conducting inquiry, exploration, and analysis in the science lab fosters students' mastery of science and engineering practices (SEPs) by promoting their ability to use clear and accurate academic language, keep detailed records, utilize technology and digital learning tools, make oral and written presentations, defend claims based on evidence from scientific investigations, and utilize age-appropriate measurement, units, and scientific tools.

Connections

- Cross-curricular connections - Teaching science in context with other subjects and with all science domains produces deeper learning and better retention. Students must utilize language and mathematical skills to access and apply science knowledge. In addition, historical context should be included when discussing how scientific knowledge has progressed over time.
- Community connections – Students use learning both within and beyond the classroom to interact and collaborate in their community and the globalized world.

6. In science classrooms and laboratories, safety must be prioritized to minimize risk in hands-on environments.

While laboratory investigations are necessary for effective science learning, they increase the potential for accidents and injuries. Safety is a primary concern for everyone involved in K-12 science instruction, including students, teachers, support personnel, and administrators. Safety must be a priority in the storage, use, and care of equipment, specimens, and materials in the science classroom. It is strongly recommended that science teachers adhere to standards from professional organizations and local, state, and national regulatory agencies such as the American Chemical Society (ACS) and the Occupational Safety and Health Administration (OSHA).

The following requirements must be met to ensure a safe learning environment in the lab:

- Teachers must follow the Alabama K-12 Science Safety Guidelines. Each district and school should develop a written safety plan based on local and state guidelines. Information on developing a safety plan can be located on the NSTA Safety and School Science Instruction page.

- Before allowing students to participate in scientific investigations, teachers must identify any potential for harm and take action to prevent possible injuries or accidents and to minimize the impact of injuries or accidents if prevention is not successful.
- Teachers must be certain that students receive adequate instruction for participating safely in all science investigations, no matter the location.
- Teachers must follow provisions set forth in the safety goggle law found in the Code of Alabama, 1975, §16-1-7, which requires local boards of education to provide American National Standards Institute (ANSI) Z87 or Z87.1 coded safety goggles to every student engaged in science experiments.

The course of study committee and task force supports the following recommendations:

- All science teachers should be certified in first aid. Professional learning information may be obtained from the American Red Cross.
- Science laboratory classes should contain no more than 24 students so that they will have adequate space to collaborate and investigate safely, as recommended by science professional organizations.

DIRECTIONS FOR INTERPRETING CONTENT STANDARDS

The illustrations below are guides for interpreting the Grades K-12 minimum required content outlining what students should know and be able to do at the end of a grade or course.

CONTENT STANDARDS FOR EACH GRADE

Academic content standards in this document are divided into grade bands: K-2, 3-5, 6-8, and 9-12. Each band contains an overview that provides general information regarding student capabilities, the classroom environment, and science instruction. More specific information for each grade level or course, including scientific and engineering practices, crosscutting concepts, and disciplinary core ideas, is provided in the description that precedes the content standards for each grade or course.

Disciplinary Core Ideas are the key organizing principles from the domains of the physical sciences, life sciences, and Earth and space sciences. The core ideas are recurring ideas that are taught and learned across multiple grades at increasing levels of depth and rigor. Core ideas prepare younger students for broader understanding and deeper levels of investigation in high school and beyond.

Related content standards are grouped under **Topics**. In the example below, the topic is "Human Impact." Standards from different topics may be closely related. Standards are also grouped by **Crosscutting Concepts** whenever appropriate.

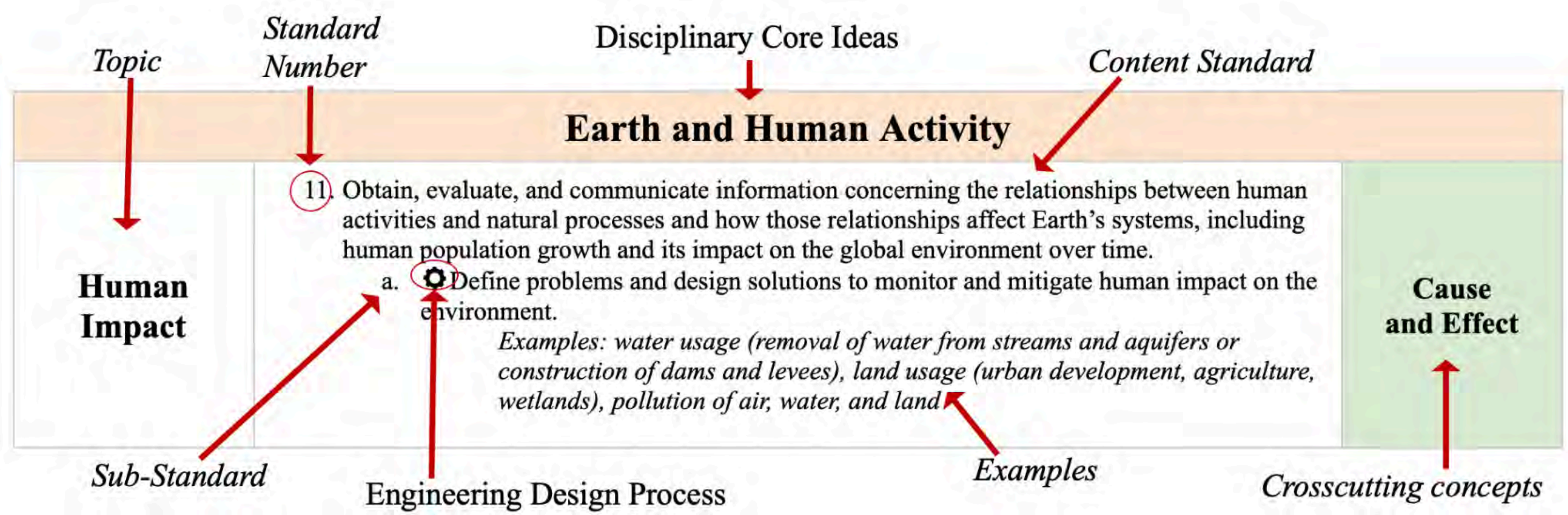
Content Standards are written below each disciplinary core idea as indicated in the illustration. These assessable statements contain the minimum required content and define what students should know and be able to do at the conclusion of a grade or course. Each content standard completes the phrase *"Students will..."* Some have extensions of standards, indicated with a, b, c, d… These **sub-standards** are of equal importance and must be included in instruction.

Some standards are followed by italicized **examples**, which provide guidance for instruction of the standard. Examples are not intended to be exhaustive lists and are not required to be taught. Some standards are accompanied by **clarifications** which further delineate the scope of the standard.

The disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain are incorporated into content standards through the use of engineering practices. Standards embodying engineering practices are included at every grade level and are preceded by a gear icon ⚙. They require students to use the engineering design process, which involves designing solutions for problems, testing the solutions, and refining the design, or to understand links among engineering, technology, science, and society.

When "including" appears in standards, it should be construed as "including but not limited to." The items listed after "including" must be taught; others may also be incorporated in instruction.

The course of study does not dictate curriculum, teaching methods, or sequence. The order in which standards are listed within a course or grade is not intended to convey the order for instruction. Even though one topic may be listed before another, the first topic does not have to be taught before the second. A teacher may choose to teach the second topic before the first, to teach both at the same time to highlight connections, or to select a different topic that leads to students reaching the standards for both topics. The standards in each course are to be used as a minimal framework and should encourage innovation. Each local education agency should create its own curriculum and pacing guide based on the course of study. Local education agencies (LEAs) may add standards to meet local needs and incorporate local resources.



Grades K-2 Overview

Effective science instruction includes strategies guided by content standards that address scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. The science content for Grades K-2 creates a sound basis for scientific exploration and the acquisition of knowledge and skills in a developmentally appropriate manner.

Science and Engineering Practices

Science and engineering practices (SEPs) help students understand the development of scientific knowledge, the work of engineers, and the connections between them. When students are given opportunities to engage in these practices, they are able to expand, strengthen, and apply their knowledge of core ideas and crosscutting concepts. Students can use SEPs in any order to explore the many applications of science and the disciplines of engineering.

SEPs encapsulate an essential dimension of science learning. They outline what students should be doing as they study science, and proficiency with these practices is critical. The SEPs are identified and explained at the beginning of each grade band and are to be incorporated across all grades. SEPs for each grade band build on related experiences in previous years and progress to increasingly complex applications.

For example, the SEP *Analyzing and Interpreting Data* focuses on “collecting, recording, and sharing observations” in Grades K-2. In Grades 3-5, students utilizing this SEP will progress to “introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations, using digital tools whenever possible.” In Grades 6-8, students will be “extending quantitative analysis to investigations, distinguishing between correlation and causation, and employing basic statistical techniques of data and error analysis.” In Grades 9-12, students will use “more detailed statistical analysis,” compare “data sets for consistency,” and use “models to generate and analyze data.”

The chart below highlights how the SEPs are utilized in Grades K-2, and can answer the question, “What are students doing when they engage in this practice in this grade band?”

Science and Engineering Practices (SEPs) Grades K-2 SEPs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.* All K-2 SEPs build on students' life experiences and previous instruction.	
Asking Questions and Defining Problems	Formulating simple descriptive questions that can be tested.
Developing and Using Models	Using and developing models that represent concrete events or design solutions, including diagrams, drawings, physical replicas, dioramas, dramatizations, or storyboards.
Planning and Carrying Out Investigations	Designing and conducting simple investigations, based on fair tests, which provide data to support explanations or design solutions.
Analyzing and Interpreting Data	Collecting, recording, and sharing observations.
Using Mathematics and Computational Thinking	Recognizing ways that mathematics can be used to describe the natural and designed world(s).
Constructing Explanations and Designing Solutions	Using evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.
Engaging in Argument from Evidence	Comparing ideas and representations about the natural and designed world(s).
Obtaining, Evaluating, and Communicating Information	Using observations and texts to gather and communicate new information.

Crosscutting Concepts

Crosscutting concepts (CCCs) are ideas that pertain to all domains of science and link the domains together. They are essential elements for interconnecting knowledge from different fields into a coherent and scientifically-based understanding of the natural world. The knowledge framework provided by CCCs allows students to connect their prior experiences with newly-acquired knowledge of science and engineering to develop a broad conception of the workings of science. Crosscutting concepts are one of the three dimensions included in each standard, along with disciplinary core ideas and science and engineering practices. Explicit instruction on these common themes should be included in all grade bands and content areas. The chart at the beginning of each grade band indicates how each crosscutting concept is expressed in the grades of that band.

Crosscutting Concepts (CCCs) **Grades K-2** **CCCs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.***	
Patterns	Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence.
Cause and Effect: Mechanism and Prediction	Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute students' ideas about causes.
Scale, Proportion, and Quantity	Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). Standard units are used to measure length.
Systems and System Models	Objects and organisms can be described in terms of their parts. Systems in the natural and designed world have parts that work together.
Energy and Matter: Flows, Cycles, and Conservation	Objects may break into smaller pieces, be put together into larger pieces, or change shapes.
Structure and Function	The shape and stability of structures of natural and designed objects are related to their function(s).
Stability and Change	Some things stay the same while other things change. Things may change slowly or rapidly.

Kindergarten

Kindergarten students enter school with an eagerness to explore the world around them. Although their experience and background knowledge may be limited, science instruction provides ample opportunity to develop investigative thinking, reasoning, and argumentation in the context of familiar surroundings. In kindergarten, students are developing the foundational skills necessary for future learning and success in science. Explicit science instruction is critical for developing scientific literacy and fostering students' curiosity.

Students in kindergarten are introduced to disciplinary core ideas (DCIs) from the scientific domains of physical, life, and Earth and space sciences. In studying the physical sciences core idea, "Motion and Stability: Forces and Interaction," students will plan and carry out developmentally appropriate investigations about changes in motion. In the life sciences core idea, "Ecosystems: Interactions, Energy, and Dynamics," students will observe phenomena, gather information, and use models to explore and explain the natural world close to them. In the Earth and space sciences DCIs, "Earth's Systems" and "Earth and Human Activity," students observe the effects of sunlight and study weather patterns.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through guided participation in the engineering design process, students will design ways to reduce the effects of sunlight and design possible solutions to lessen human impact on the environment.

Each content standard completes the stem *"**Students will**…"*

Motion and Stability: Forces and Interactions		
Changes in Motion	1. Plan and carry out investigations to determine the effects of forces of different strengths and directions on the motion of an object, including speed, direction, and distance traveled. *Examples: pushing, pulling, or crashing objects* 2. Analyze data from investigations to determine whether a design solution provides sufficient force to change the speed or direction of an object. *Example: constructing a ramp to increase or decrease the speed of a moving object*	**Cause and Effect**

Ecosystems: Interactions, Energy, and Dynamics		
Structures and Processes	3. Use data from observations to distinguish characteristics of living and nonliving things. 4. Use observations to determine patterns of what plants and animals (including humans) need to survive, including light, water, and nutrients.	**Patterns**
Interdependent Relationships	5. Gather information from observations and media to explain how plants and animals can provide for their needs by changing their environment. *Examples: tree roots breaking a sidewalk to provide space, red fox burrowing to create a den to raise young, humans growing gardens for food and building roads for transportation, birds and beavers using available materials to construct their homes* 6. Use models of natural habitats to represent the interdependence among plants and animals native to their community. *Examples: school garden, terrarium, aquarium, classroom animal habitat (worms, geckos, butterflies), virtual habitat models*	**Systems and System Models**
Earth's Systems		
Energy Transfer	7. Make observations and describe the effects of sunlight on Earth's surface. *Examples: evaporation of water or increased temperature of soil, rocks, and sand caused by direct and indirect sunlight* 8. Design, construct, and test a device to reduce the effects of sunlight. *Examples: hat, canopy, umbrella, tent*	**Cause and Effect**
Weather	9. Observe, record, and communicate local weather patterns over a period of time. *Examples: daily increase in temperature from morning to afternoon, typical rain and storm patterns from season to season* 10. Obtain, evaluate, and communicate information about using weather forecasts to make plans and prepare for severe weather.	**Patterns**

Earth and Human Activity		
Human Impact	11. Identify a problem and design possible solutions that lessen the human impact on the local environment. *Examples: Notice trash accumulating on the playground and come up with a plan to address it; observe gravel washing from a driveway onto a grassy area and create a barrier to keep the rocks in place.*	**Cause and Effect**

Grade 1

First grade students continue to be eager learners who are curious about their world. This inquisitive nature leads them to ask a variety of questions to create deeper understanding. Students are developing social skills that enable them to engage in cooperative, inquiry-based learning, and they begin to take ownership of their learning experiences by making connections through meaningful investigations. Explicit science instruction is critical for developing scientific literacy and fostering students' curiosity.

Students in Grade 1 learn disciplinary core ideas (DCIs) from the scientific domains of physical, life, and Earth and space sciences. In the physical sciences, addressed through the core idea "Waves and Their Applications in Technologies for Information Transfer," students conduct investigations to discover the properties of light and sound waves. In the life sciences DCIs, "From Molecules to Organisms: Structures and Processes" and "Heredity: Inheritance and Variation of Traits," students identify similarities between parents and their offspring and determine how organisms adapt to their environment in order to survive. In the Earth and space sciences core idea, "Earth's Place in the Universe," students observe and predict seasonal patterns of daylight and observe the patterns of the sun, moon, and stars as they appear in the sky.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon ⚙. Through guided participation in the engineering design process, students construct a device that uses light or sound to communicate.

Each content standard completes the stem *"**Students will**…"*

Waves and Their Applications in Technologies for Information Transfer		
Wave Properties	1. Carry out investigations to provide evidence that the vibrations of matter can make sound and sound can make matter vibrate. *Examples: striking a tuning fork, plucking a guitar string, holding a piece of paper near a sound system speaker* 2. Use evidence from observations to explain that light is necessary in order for an object to be seen. 3. Plan and carry out investigations to determine how light is affected when it interacts with various types of materials. *Examples: transparent, translucent, opaque, reflective*	**Cause and Effect**

	4. Design and construct a device that uses light or sound waves to send a communication signal over a distance. *Examples: using a light or a sound to communicate an action or a warning*	
From Molecules to Organisms: Structures and Processes		
External Structures	5. Use information from observations to explain how various external features help living things survive, grow, and meet their needs. *Examples: a rose's thorns, a giraffe's long neck*	**Structure and Function**
Growth and Development	6. Obtain information from text and other media to provide evidence that parents and their offspring engage in patterns of behavior that help the offspring survive. *Examples: Offspring send signals such as crying or other vocalization and the parent responds by comforting, feeding, and protecting the offspring.*	**Patterns**
Heredity: Inheritance and Variation of Traits		
Inherited Traits and Environmental Impact	7. Make observations to identify the similarities and differences between offspring and their parents. *Examples: flowers from the same kind of plant being the same shape, but differing in size; dog being same breed as parent, but differing in fur color or pattern*	**Patterns**
Earth's Place in the Universe		
Sun, Moon, and Stars	8. Observe, describe, and predict patterns of the sun, moon, and stars as they appear in the sky. 9. Use observations of seasonal sunrise and sunset patterns to describe the relationship between the number of hours of daylight and the time of year.	**Patterns**

Grade 2

Students enter second grade with prior knowledge and skills that enable them to formulate answers to questions as they expand their comprehension of the world around them. Through continued exploration, they acquire new information and construct models. Explicit science instruction is critical for developing scientific literacy and fostering students' curiosity.

Students in Grade 2 learn disciplinary core ideas from the scientific domains of physical, life, and Earth and space sciences. In the physical sciences core idea, "Matter and Interactions," students explore the physical properties and structure of matter. In the core idea from life sciences, "Ecosystems: Interactions, Energy, and Dynamics," students explore plant needs and interactions among living things within habitats. In the Earth and space sciences core idea, "Earth's Systems," students identify and simulate Earth's events and physical features.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon ⚙. Through guided participation in the engineering design process, students investigate and model how plants depend on animals for seed dispersal and pollination and how to address changes caused by Earth's events.

Each content standard completes the stem *"**Students will**…"*

Matter and Its Interactions		
Structure and Properties	1. Plan and carry out investigations to compare, contrast, and classify various solid and liquid materials according to physical properties, including color and texture. 2. Conduct investigations to determine suitable uses of natural and manufactured materials based on their observable properties, including strength, flexibility, hardness, absorbency, and texture.	**Structure and Function**
Physical and Chemical Changes	3. Demonstrate and explain how structures made from a small set of pieces can be disassembled and then reassembled as new and different structures. 4. Provide evidence that some changes in matter caused by heating or cooling can be reversed and some changes are irreversible.	**Stability and Change**

Ecosystems: Interactions, Energy, and Dynamics		
Interdependent Relationships	5. Plan and carry out an investigation, using one variable at a time, to determine how each variable affects plant growth. *Examples: various amounts of light, various amounts of water*	**Cause and Effect**
	6. ✿Design and construct models to simulate how animals disperse seeds or pollinate plants.	**Structure and Function**
Biodiversity	7. Obtain information to explain that there are many different kinds of living things that exist in habitats on land and in water.	**System and System Models**
Earth's Systems		
Physical Features	8. Use models to distinguish between the shapes and kinds of land and water on Earth. *Examples: rivers, oceans, mountains, valleys*	**Patterns**
Water	9. Obtain information to identify where water is found on Earth and determine whether it is a solid or a liquid.	**Scale, Proportion, and Quantity**
Changes Over Time	10. Use a variety of sources to provide evidence that Earth's events can occur slowly or rapidly. *Examples: erosion, melting of glaciers; earthquakes, volcanic eruptions*	**Stability and Change**
Human Impact	11. ✿Evaluate multiple solutions designed to slow or prevent wind or water from changing the shape of Earth's surface. *Examples: the use of dams and erosion prevention methods*	**Cause and Effect**

Grades 3-5 Overview

Effective science instruction includes strategies guided by content standards that address scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. The science content for Grades 3-5 expands upon the skills and concepts taught in earlier grades. It challenges students to design solutions to problems stemming from real-world scenarios.

Science and Engineering Practices

Science and engineering practices (SEPs) help students understand the development of scientific knowledge, the work of engineers, and the connections between them. When students are given opportunities to engage in these practices, they are able to expand, strengthen, and apply their knowledge of core ideas and crosscutting concepts. Students can use SEPs in any order to explore the many applications of science and the disciplines of engineering.

SEPs encapsulate an essential dimension of science learning. They outline what students should be doing as they study science, and proficiency with these practices is critical. The SEPs are identified and explained at the beginning of each grade band and are to be incorporated across all grades. SEPs for each grade band build on related experiences in previous years and progress to increasingly complex applications.

For example, the SEP *Analyzing and Interpreting Data* focused on “collecting, recording, and sharing observations" in Grades K-2. In Grades 3-5, students utilizing this SEP will progress to “introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations, using digital tools whenever possible.” In Grades 6-8, students will be “extending quantitative analysis to investigations, distinguishing between correlation and causation, and employing basic statistical techniques of data and error analysis.” In Grades 9-12, students will use “more detailed statistical analysis,” compare “data sets for consistency,” and use “models to generate and analyze data.”

The chart below highlights how the SEPs are utilized in Grades 3-5, and can answer the question, “What are students doing when they engage in this practice in this grade band?”

Science and Engineering Practices (SEPs) Grades 3-5 SEPs are taken from *The NSTA Quick Reference Guide to the Three Dimensions*	
Asking Questions and Defining Problems	Specifying qualitative relationships.
Developing and Using Models	Building and revising simple models; using models to represent events and design solutions.
Planning and Carrying Out Investigations	Designing and conducting investigations with controlled variables; providing evidence to support explanations or design solutions.
Analyzing and Interpreting Data	Introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations, using digital tools whenever possible.
Using Mathematics and Computational Thinking	Extending quantitative measurements to a variety of physical properties; using computation and mathematics to analyze data and compare alternative design solutions.
Constructing Explanations and Designing Solutions	Using evidence in constructing explanations that specify variables, describing and predicting phenomena, and designing multiple solutions to design problems.
Engaging in Argument from Evidence	Critiquing the scientific explanations or solutions proposed by peers, citing relevant evidence about the natural and designed world(s).
Obtaining, Evaluating, and Communicating Information	Evaluating the merit and accuracy of ideas and methods.

Crosscutting Concepts

Crosscutting concepts (CCCs) are ideas that pertain to all domains of science and link the domains together. They are essential elements for interconnecting knowledge from different fields into a coherent and scientifically-based understanding of the natural world. The knowledge framework provided by CCCs allows students to connect their prior experiences with newly-acquired knowledge of science and engineering to develop a broad conception of the workings of science. Crosscutting concepts are one of the three dimensions included in each standard, along with disciplinary core ideas and science and engineering practices, and explicit instruction on these common themes should be included in all grade bands and content areas. The chart at the beginning of each grade band indicates how each crosscutting concept is expressed in the grades of that band.

Crosscutting Concepts (CCCs) Grades 3-5 CCCs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.*	
Patterns	Similarities and differences in patterns can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products. Patterns of change can be used to make predictions. Patterns can be used as evidence to support an explanation.
Cause and Effect: Mechanism and Prediction	Cause and effect relationships are routinely identified, tested, and used to explain change. Events that occur together with regularity might or might not be a cause and effect relationship.
Scale, Proportion, and Quantity	Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.
Systems and System Models	A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.
Energy and Matter: Flows, Cycles, and Conservation	Matter is made of particles. Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. Energy can be transferred in various ways; energy can be transferred between objects.
Structure and Function	Different materials have different substructures, which can sometimes be observed. Substructures have shapes and parts that serve functions.
Stability and Change	Change is measured in terms of differences over time and may occur at different rates. Some systems appear stable, but over long periods of time will eventually change.

Grade 3

Third grade students have a growing capacity to process information. They are increasingly aware of their environment and have already developed an understanding of many patterns and processes in nature. This awareness makes them eager to participate in scientific and engineering practices. Students use writing and mathematics skills to communicate scientific information during varied instructional activities. Explicit science instruction is critical for applying scientific literacy to make connections between academic content and the world around them.

Students in Grade 3 will learn disciplinary core ideas from the scientific domains of physical, life, and Earth and space sciences. The physical sciences domain addresses the core idea “Motion and Stability,” in which students will investigate, measure, and predict the motion of an object and test the cause and effect relationship of electrostatic and magnetic interactions. Life sciences encompasses “Structures and Processes,” “Inheritance and Variation of Traits,” and “Unity and Diversity.” Students use evidence to interpret fossil data and construct explanations of an organism’s ability to survive when environmental changes occur. Students examine organisms’ life cycles and traits and the influence of the environment on these traits. Earth and space sciences core ideas are “Earth’s Systems” and “Earth and Human Activity.” Students represent data and communicate solutions to problems that exist in typical weather conditions expected during a particular season.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon. Through guided participation in the engineering design process, students will solve a problem by applying scientific ideas about magnetic interactions.

Each content standard completes the stem *"**Students will**…"*

Motion and Stability: Forces and Interactions		
Changes in Motion	1. Conduct investigations to explain the effects of balanced and unbalanced forces exerted on an object, varying the size, number, and direction of the forces. *Examples: balanced forces pushing from both sides of an object, such as a box, producing no motion; unbalanced force on one side of an object, such as a ball, producing motion*	**Cause and Effect**
	2. Observe and measure an object's motion to provide evidence that a pattern of motion can be used to predict future motion. *Examples: a child swinging on a swing, a ball rolling back and forth in a bowl, two children going up and down on a seesaw, a model vehicle rolling down ramps of varying heights, a swinging pendulum*	**Patterns**
Non-Contact Forces	3. Conduct investigations to determine cause and effect relationships between objects not in contact with one another, including magnetic and electrostatic forces. *Examples: the force on hair from an electrically charged balloon, the attraction of the plastic wrap to your hand after you remove it from a package, force between two permanent magnets at a distance, force between two magnets and steel paper clips*	**Cause and Effect**
	4. Apply scientific ideas about magnetic interactions to solve a problem using the engineering design process. *Examples: constructing maglev systems, constructing a latch to keep a door shut*	**Systems and System Models**

From Molecules to Organisms: Structures and Processes		
Growth and Development	5. Develop and use models to compare the diverse life cycles of organisms other than humans, including birth, growth, reproduction, and death. *Examples: flowering plants, frogs, butterflies*	**Stability and Change**
Heredity: Inheritance and Variation of Traits		
Inherited Traits and Environmental Impact	6. Use data to provide evidence that plants and animals have observable traits inherited from parents and that variations of these traits exist in groups of similar organisms. *Examples: dogs and their offspring have fur and four legs, pine trees and their offspring have needles*	**Patterns**
	7. Use evidence to support a claim that traits can be influenced by the environment. *Examples: insufficient nutrients leads to stunted growth in plants and animals; acid in the soil determines the color of the hydrangea blooms; a flamingo's diet determines the color of its feathers*	**Cause and Effect**
Unity and Diversity		
Fossil Evidence	8. Analyze and interpret data from fossils to provide evidence of the existence of organisms and information about the environments in which they lived. *Examples: marine fossils on dry land, tropical plant fossils in arctic areas, fossils of extinct organisms in any environment*	**Scale, Proportion, and Quantity**

Biodiversity	9. Construct an explanation from evidence of how variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. *Examples: plants having larger thorns being less likely to be eaten by predators, animals having better camouflage coloration being more likely to survive and bear offspring*	**Systems and System Models**
	10. Make a claim from evidence that an organism's likelihood of survival depends upon access to sufficient resources in its habitat, including sunlight, air, water, food, and shelter.	**Energy and Matter**
	11. Construct explanations of how forming groups helps some organisms survive. *Example: quail form coveys to provide protection for their young*	**Cause and Effect**
Human Impact	12. Obtain and communicate information regarding the impact of existing solutions on plant and animal populations when environmental changes occur. *Examples: creating barriers in coastal areas to protect sea oats from destruction by hurricanes, trapping and relocating beavers whose dam causes flooding, reseeding a forest following wildfires, cutting a fire break or burning underbrush to contain a wildfire*	**Scale, Proportion, and Quantity**
Earth's Systems		
Weather	13. Represent data in tables or graphical displays to reveal typical weather patterns during a particular season. *Examples: line graphs of precipitation, bar graphs of wind direction, line plots of temperature*	**Patterns**
Climate	14. Use information from a variety of sources to describe climates in different regions of the world.	**Systems and System Models**

Earth and Human Activity		
Natural Hazard Solutions	15. Obtain and communicate information on the effectiveness of existing solutions designed to reduce the impact of weather-related hazards. *Examples: flood barriers, wind-resistant roofs, tornado warning sirens, hurricane shutters, tornado shelters, weather alert apps on a phone*	**Cause and Effect**

Grade 4

Fourth graders thrive in an active learning environment where they can manipulate physical materials and construct models. They are beginning to provide evidence to support their scientific claims and transition toward more abstract models and explanations. Explicit science instruction is critical for applying scientific literacy to make connections between academic content and the world around them.

Students in Grade 4 learn disciplinary core ideas from the scientific domains of physical, life, and Earth and space sciences. The core ideas from physical sciences are “Energy” and “Waves and Their Applications for Information Transfer.” In this domain, students construct explanations based on evidence connecting the speed of an object to its energy, including the transference of energy in its various forms, and develop a model to describe wave patterns with observable wavelengths and amplitudes. Life sciences addresses the core idea “From Molecules to Organisms,” in which students compare the internal and external structures of plants and animals and investigate ways animals process information. In Earth and space sciences, which includes “Earth’s Systems” and “Earth and Human Activity,” students construct explanations for both slow and rapid processes on Earth’s land features, describe patterns of Earth’s land and water based on maps, and gather information on various energy sources to design solutions to protect humans from natural disasters.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through guided participation in the engineering design process, students find answers regarding which components of a device change energy from one form to another, how wave patterns can be used to transfer information, and how to limit the effects of harmful natural Earth processes on human life.

Each content standard completes the stem *"**Students will**…"*

<table>
<tr><th colspan="3">Energy</th></tr>
<tr><td>Speed and Energy</td><td>1. Use evidence to explain the relationship between the speed of an object and its energy.</td><td>Cause and Effect</td></tr>
<tr><td rowspan="2">Transference of Energy</td><td>2. Plan and carry out investigations to answer questions regarding changes in energy when objects collide, and predict reasonable outcomes based on observed patterns.
Examples: marbles rolling down a ramp and colliding with each other, chain reactions with dominoes</td><td>Patterns</td></tr>
<tr><td>3. Plan and carry out investigations to provide evidence that energy is transferred by sound, light, heat, and electric currents.
Examples: creating an electric circuit that requires a complete loop
a. Construct an explanation using evidence to support the claim that heat can be produced in many ways.
Examples: rubbing hands together, burning leaves
b. Construct an explanation with evidence supporting the claim that different objects can absorb, reflect, and/or conduct energy.

4. Design, construct, and test a device that changes energy from one form to another.
Examples: electric circuits converting electrical energy into motion, light, or sound energy; a passive solar heater converting light energy into heat energy</td><td>Energy and Matter</td></tr>
</table>

Waves and Their Applications in Technologies for Information Transfer		
Wave Properties	5. Develop and use models to describe amplitude and wavelength patterns and how waves can cause objects to move.	**Patterns**
Information Transfer	6. Construct an explanation of how light, sound, and digitized information are transferred by waves. *Examples: using a grid of 1s and 0s representing black and white to send information about a picture, using drums to send coded information through sound waves, and using Morse code to send a message*	
Wave Properties	7. Develop a model to demonstrate that light reflecting from objects and entering the eyes allow objects to be seen. *Example: light reflecting off an apple and back into the eye*	**Cause and Effect**

From Molecules to Organisms: Structures and Processes		
Internal and External Structures	8. Make a claim, using evidence, that the functions of both internal and external structures of plants and animals (including humans) support growth, survival, and behavior. *Examples: In plants, thorns provide protection and stems transport nutrients; in animals, heart pumps blood and skin provides protection.* **Clarification: The emphasis is on the function of individual structures.**	**Structure and Function**
Information Processing	9. Carry out investigations to support a claim that different animals receive information through their senses, process that information, and respond in various ways. *Examples: earthworms tunneling into the soil to avoid light, frogs jumping when startled, dogs moving their ears when reacting to sound*	**Systems and System Models**

Earth's Systems		
Water	10. Develop and use a model to describe how water moves through Earth's systems by the processes of evaporation, condensation, and precipitation.	**Systems and System Models**
Changes Over Time	11. Construct explanations of Earth's changes over time through slow and rapid processes, citing evidence found in rock formations and fossils in rock layers. *Examples: rock layers containing shell fossils appearing above rock layers containing plant fossils but no shells, indicating a change from land to water over time; a canyon with rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock*	**Stability and Change**
	12. Plan and carry out investigations to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, and vegetation, investigating a single form of weathering or erosion at a time. *Examples: angle of slope in downhill movement of water flow, cycles of freezing and thawing of water, cycles of heating and cooling water, speed of wind, relative rate of soil deposition, amount of vegetation compared to rate of erosion*	**Scale, Proportion, and Quantity**
Physical Features	13. Analyze and interpret data from maps to describe patterns of Earth's features on land and in the ocean. *Examples: topographic maps of Earth's land and ocean floor; maps of mountains, continental boundaries, volcanoes, and earthquakes*	**Patterns**

<table>
<tr><th colspan="3">Earth and Human Activity</th></tr>
<tr><td>Natural Resources</td><td>14. Gather information to describe how the use of energy derived from renewable and nonrenewable resources affects the environment.
Examples: Constructing dams harnesses energy from water and changes animal habitats. Burning fossil fuels creates energy and creates air pollution.</td><td rowspan="2">Cause and Effect</td></tr>
<tr><td>Natural Hazard Solutions</td><td>15. ✪Design, test, and evaluate a solution that will protect humans from the effects of natural Earth processes.
Examples: designing buildings to resist earthquakes, tornados, or hurricanes; improving monitoring of volcanic activity</td></tr>
</table>

Grade 5

Fifth grade students are scientific thinkers who have developed many skills that enable them to conduct more refined measurements of data and communicate scientific information with greater detail through various forms of presentation. They can plan and carry out investigations, identify patterns in data, and revise design solutions. Explicit science instruction is critical for applying scientific literacy to make connections between academic content and the world around them. An encouraging and challenging learning environment can inspire fifth graders to develop a passion for science and engineering.

Students in Grade 5 learn disciplinary core ideas from the scientific domains of physical, life, and Earth and space sciences. The physical sciences domain includes "Matter and Its Interactions" and "Motion and Stability: Forces and Interactions." Students carry out investigations to provide evidence of the conservation of matter and find evidence of the gravitational force that pulls all objects toward the center of Earth. In life sciences, students explore "Ecosystems: Interactions, Energy, and Dynamics," in which they create models to explain the flow of matter in ecosystems. The Earth and space sciences domain encompasses "Earth's Place in the Universe," "Earth's Systems," and "Earth and Human Activity." Students use models to represent how systems interact and how water is distributed on Earth. Students obtain information about ways individuals and communities can protect Earth's resources and construct explanations for the patterns of seasons, day and night, and the seasonal changes of stars' visibility in the sky.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon. Through guided participation in the engineering design process, students find out what methods can be used to clean a polluted environment and determine ways to modify the speed of a falling object.

Each content standard completes the stem *"**Students will**…"*

Matter and Its Interactions		
Structure and Properties	1. Plan and carry out investigations to provide evidence that matter is made of particles too small to be seen. *Examples: adding air to expand a basketball, dissolving sugar into water*	**Scale, Proportion, and Quantity**
	2. Analyze data collected through observations and measurements to identify materials based on their properties, including color, hardness, and reflectivity.	**Structure and Function**
Physical and Chemical Changes	3. Conduct investigations to provide evidence that the total weight of matter is conserved during phase changes when substances are heated, cooled, or mixed. *Examples: melting a cube of ice in a cup of water; dissolving sugar in hot water; placing a warm water bottle in the refrigerator*	**Energy and Matter**
	4. Analyze data from tests to determine whether a new substance is formed after two or more substances are combined. *Examples: mixing vinegar and baking soda, sand and water*	**Cause and Effect**
Motion and Stability: Forces and Interactions		
Non-Contact Forces	5. Make a claim, supported by evidence, that the gravitational force exerted by Earth pulls objects towards the center of Earth.	**Systems and System Models**
	6. Design and conduct a test to modify the speed of an object falling due to gravity. *Example: constructing a parachute to slow the speed of a falling object*	**Cause and Effect**

Ecosystems: Interactions, Energy, and Dynamics

Matter and Energy Flow	7. Support an argument from evidence that plants primarily use air and water to process matter needed for growth.	**Structure and Function**
	8. Use evidence to explain that energy from the sun is present in animals' food and is used for body repair, growth, motion, and maintenance of body warmth.	**Energy and Matter**
	9. Create and use a model to explain the transfer of matter and energy between the environment and organisms within it. *Examples: producers, consumers, scavengers, decomposers*	

Earth's Place in the Universe

Sun, Moon, and Stars	10. Obtain and communicate information to explain why the sun appears to be larger and brighter than other stars.	**Scale, Proportion, and Quantity**
	11. Analyze data that reveal patterns of daily changes in length and direction of shadows, day and night, phases of the moon, and seasonal appearance of some stars in the night sky.	**Patterns**

Earth's Systems

System Interactions	12. Use a model to represent how any two of Earth's systems (atmosphere, biosphere, geosphere, and hydrosphere) interact and support life. *Example: impact of the ocean (hydrosphere) on ecosystems and landforms (geosphere); impact of mountain ranges (geosphere) on weather (atmosphere)*	**Systems and System Models**

Water	13. Construct a model to represent the distribution of freshwater and saltwater on Earth. *Example: graphical display representing the percentages of fresh and saltwater amounts*	**Scale, Proportion, and Quantity**
Earth and Human Activity		
Human Impact	14. Obtain and evaluate information to communicate how science-based solutions are being used to protect Earth's natural resources and its environment. *Examples: terracing land to prevent soil erosion, recycling to reduce overuse of landfill areas*	**Stability and Change**
	15. Design, test, and revise solutions to clean a polluted environment. *Examples: simulating a solution to an oil spill in the ocean, simulating using plants to clean contaminated environments (phytoremediation)*	

Grades 6-8 Overview

Science in the middle grades is a gateway to a world of wonder and discovery, which aims to foster curiosity, critical thinking, and a basic understanding of scientific principles. Teachers should strive to nurture inquisitive minds, foster a love for learning, and encourage students to view the world through a scientific lens. Engaging students in the wonder of science sets the stage for future scientific pursuits in the realms of Earth systems, biology, chemistry, physics, and beyond. As students navigate the terrain of science in the middle grades, they do not merely learn about the world; they become explorers, investigators, and stewards of our planet. With each lesson, experiment, and discovery, they move a step closer to understanding scientific phenomena and shaping a brighter future. Throughout this journey, students learn to question, make predictions, perform experiments, and analyze data. Students sharpen their critical thinking skills, armed with the tools needed to solve complex problems and explore the unknown.

Students are becoming more independent learners as they transition from middle grades to high school. Their sense of curiosity and discovery must be fostered to encourage development of the self-discipline needed for mastery of concepts at a higher level of proficiency. Students' increasing academic and social maturity enables them to discuss content in depth and to utilize reading and mathematical skills in the science classroom. Students will be encouraged to ask questions, engage in argument from evidence, and construct explanations to correct scientific misconceptions. Teachers must provide hands-on opportunities for students to interact with peers in a collaborative setting, using scientific concepts and processes to develop explanations and design solutions for real-world problems. Students must engage in science and engineering practices in an active learning environment in order to improve critical thinking skills.

Science and Engineering Practices

Science and engineering practices (SEPs) help students understand the development of scientific knowledge, the work of engineers, and the connections between them. When students are given opportunities to engage in these practices, they are able to expand, strengthen, and apply their knowledge of core ideas and crosscutting concepts. Students can use SEPs in any order to explore the many applications of science and the disciplines of engineering.

SEPs encapsulate an essential dimension of science learning. They outline what students should be doing as they study science, and proficiency with these practices is critical. The SEPs are identified and explained at the beginning of each grade band and are to be incorporated across all grades. SEPs for each grade band build on related experiences in previous years and progress to increasingly complex applications.

For example, in Grades K-2 the SEP *Analyzing and Interpreting Data* focused on "collecting, recording, and sharing observations." In Grades 3-5, students utilizing this SEP progressed to "introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations, using digital tools whenever possible." In Grades 6-8, students will be "extending quantitative analysis to investigations, distinguishing between correlation and causation, and employing basic statistical techniques of data and error analysis." In Grades 9-12, students will use more detailed statistical analysis, compare data sets for consistency, and use models to generate and analyze data.

The chart below highlights how the SEPs are utilized in Grades 6-8, and can answer the question, "What are students doing when they engage in this practice in this grade band?"

Science and Engineering Practices (SEPs) **Grades 6-8** **SEPs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.***	
Asking Questions and Defining Problems	Specifying relationships between variables, clarifying arguments, and models.
Developing and Using Models	Developing, utilizing, and revising models to describe, test, and predict more abstract phenomena and to design systems.
Planning and Carrying Out Investigations	Designing and conducting investigations that use multiple variables and provide evidence to support explanations or solutions.
Analyzing and Interpreting Data	Extending quantitative analysis to investigations, distinguishing between correlation and causation, and employing basic statistical techniques of data and error analysis.
Using Mathematics and Computational Thinking	Identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.
Constructing Explanations and Designing Solutions	Constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
Engaging in Argument from Evidence	Constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
Obtaining, Evaluating, and Communicating Information	Evaluating the merit and validity of ideas and methods.

Crosscutting Concepts

Crosscutting concepts (CCCs) are ideas that pertain to all domains of science and link the domains together. They are essential elements for interconnecting knowledge from different fields into a coherent and scientifically-based understanding of the natural world. The knowledge framework provided by CCCs allows students to connect their prior experiences with newly-acquired knowledge of science and engineering to develop a broad conception of the workings of science. Crosscutting concepts are one of the three dimensions included in each standard, along with disciplinary core ideas and science and engineering practices, and explicit instruction on these common themes should be included in all grade bands and content areas. The chart at the beginning of each grade band indicates how each crosscutting concept is expressed in the grades of that band.

Crosscutting Concepts (CCCs) **Grades 6-8** **CCCs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.***	
Patterns	Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems. Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data.
Cause and Effect: Mechanism and Prediction	Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can be described only by using probability.
Scale, Proportion, and Quantity	Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. The observed function of natural and designed systems may change with scale. Proportional relationships among different types of quantities (e.g., speed as the ratio of distance traveled to time taken) provide information about the magnitude of properties and processes. Scientific relationships can be represented through the use of algebraic expressions and equations. Phenomena that can be observed at one scale may not be observable at another scale.
Systems and System Models	Systems may interact with other systems; they may have sub-systems and may be part of larger complex systems. Models can be used to represent systems and their interactions (such as inputs, processes and outputs) and energy,

	matter, and information flow within systems. Models are limited in that they represent only certain aspects of the system under study.
Energy and Matter: Flows, Cycles, and Conservation	Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.
Structure and Function	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures and systems can be analyzed to determine how they function. Structures can be designed to serve particular functions by taking into account the properties of different materials and how materials can be shaped and used.
Stability and Change	Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. Small changes in one part of a system might cause large changes in another part. Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Systems in a dynamic equilibrium are stable due to a balance of feedback mechanisms.

Grade 6
Earth and Space Science

Earth and Space Science content focuses on the disciplinary core ideas in the Earth and space sciences domain. The first core idea, “Earth’s Place in the Universe,” describes the universe as a whole and addresses its grand scale in both space and time. The second and third core ideas, “Earth’s Systems: Materials and Processes” and “Earth’s Systems: Energy and Weather,” encompass the processes that produce Earth’s continuously changing conditions. The fourth core idea, “Earth and Human Activity,” addresses society’s interactions with the planet.

Sixth grade students will develop and use models, analyze and interpret data, and construct explanations to gain a better understanding of Earth’s systems and Earth’s place in the universe. They will carry out investigations and utilize their findings as evidence in order to construct their own understanding of Earth. As they obtain, analyze, and utilize data, students are encouraged to develop solutions to conserve Earth’s natural resources and limit the negative impact humans may have on the planet.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon. Through guided participation in the engineering design process, students will design solutions to mitigate real-world problems including the impact of severe weather and human activity on the environment.

Each content standard completes the stem *"**Students will**…"*

Earth's Place in the Universe		
Sun, Earth, and Moon	1. Manipulate models to demonstrate the patterns of motion of the sun, Earth, and moon.	**Patterns**
	a. Construct an evidence-based explanation of how the relative positions of the sun and Earth result in observable phenomena, including day and night cycles, length of year, and seasons. b. Construct an evidence-based explanation of how the relative positions of the sun, moon, and Earth result in observable phenomena, including lunar cycles, eclipses, and tidal cycles.	**Cause and Effect**
The Solar System and the Universe	2. Evaluate information to compare and contrast past and current views about the structure of the universe and show how these views have changed over time. *Example: structure of the solar system (heliocentric vs. geocentric)*	**Patterns**
	3. Construct an evidence-based explanation of the role of gravity on the movement of natural and manmade objects within galaxies and the solar system. *Examples: planets, moons, comets, asteroids, meteors, satellites*	**Systems and System Models**
	4. Analyze and use data to determine scale properties and characteristics of objects in the solar system including sizes, distances, orbital periods, basic composition, and ability to support life.	**Scale, Proportion, and Quantity**

Earth's Systems: Materials and Processes		
Earth's Processes	5. Obtain, evaluate, and communicate evidence that explains how constructive and destructive processes shape Earth's surface. a. Develop and use models to demonstrate the processes that form rocks and cycle Earth's materials. *Examples: crystallization, heating and cooling, weathering and erosion* b. Construct an evidence-based explanation of how rocks are classified as metamorphic, igneous, or sedimentary based on their characteristics and the process of the rock cycle. c. Develop and use models to demonstrate types of weathering, effects of agents of erosion and transportation, and the formation of environments of deposition. *Examples: physical and chemical weathering; water, wind, ice, and vegetation; deltas, alluvial fans, sand dunes* d. Use research-based evidence to propose a scientific explanation of how the distribution of Earth's resources, including minerals, fossil fuels, and groundwater, results from ongoing geoscience processes.	**Cause and Effect**
Plate Tectonics	6. Construct an evidence-based explanation of how tectonic plate movement impacts Earth's surface over geological time. *Examples: formation of canyons, caverns, volcanic island chains* a. Construct an evidence-based explanation of how Earth's internal energy flows between its surface and its interior. *Examples: transfer of heat from the core to crust; convection currents due to differences in density* b. Construct a scientific explanation of how the movement of lithospheric plates can cause major geologic events and form Earth's surface features, including convergent, divergent, and transform boundaries; earthquakes; and volcanoes. c. Provide evidence of past plate movements, using data regarding the distribution of fossils, rocks, continental shapes, and seafloor structures.	**Energy and Matter**

	7. Analyze data from rock strata and the fossil record to construct a chronology of occurrences in Earth's history. *Examples: fossil evidence, sedimentary rock layers, impact craters, and volcanic eruptions*	
	Earth's Systems: Energy and Weather	
Energy Transfer	8. Construct an evidence-based explanation of how the sun's energy drives the motion and cycling of water through the hydrosphere. a. Plan and carry out an investigation to determine the differences in rates of energy transfer from the sun to air, to land, and to water via conduction, convection, and radiation. b. Develop and use a model that illustrates how differences in heat and pressure affect density and the relationship between density and convection.	**Systems and System Models**
Weather	9. Use data analysis to monitor and predict weather changes and the impact of weather events, including severe weather. *Example: Track and analyze temperature and barometric pressure data collected for the local area to identify trends that result in weather changes, and use this analysis to predict future weather events in the area.* a. Obtain, evaluate, and communicate data that describes characteristics of air masses, including temperature, pressure, and humidity. *Examples: weather maps, diagrams, radar, and computer simulations* b. Construct an explanation of how air pressure, weather fronts, and air masses are related to weather events. c. Design solutions to mitigate the impact of severe weather. *Examples: storm shelter, action plan, weather monitoring tools*	**Stability and Change**

Climate	10. Use observations and data from investigations to demonstrate how the sun, air, land, and water affect Earth's climate. *Examples: simulations of convection in the atmosphere and ocean, comparisons of how soil and water absorb heat* a. Develop models demonstrating how unequal heating and the rotation of the Earth cause local and global wind systems and oceanic currents. b. Construct explanations of how the tilt and curvature of the Earth cause unequal heating of its surface, resulting in regional climates based on patterns of latitude. c. Construct an explanation of how altitude, geothermal activity, and oceanic distribution of heat produce typical regional climate patterns. *Examples: mountains, geothermal features in Iceland, California currents*	**Patterns**
	Earth and Human Activity	
Human Impact	11. Obtain, evaluate, and communicate information concerning the relationships between human activities and natural processes and how those relationships affect Earth's systems, including human population growth and its impact on the global environment over time. a. Define problems and design solutions to monitor and mitigate human impact on the environment. *Examples: water usage (removal of water from streams and aquifers or construction of dams and levees), land usage (urban development, agriculture, wetlands), pollution of air, water, and land*	**Cause and Effect**

Grade 7
Life Science

Grade 7 Life Science is designed to provide students with a foundation of scientific knowledge and ways of exploring the world. It provides an understanding of living organisms, from the smallest cells to complex ecosystems, allowing students to appreciate the diversity and complexity of life on Earth. Life Science not only imparts knowledge about the natural world but also nurtures critical thinking, ethical reasoning, and practical skills that are valuable in numerous aspects of life and future career paths. This course requires comprehensive learning and the use of reading, writing, and mathematics skills to enhance scientific literacy.

Life Science content focuses on the disciplinary core ideas in the life sciences domain. The first disciplinary core idea, “From Molecules to Organisms: Structures and Processes,” focuses on cellular structures, energy, mitosis, and interaction of body systems necessary for growth, development, and maintenance of homeostasis, emphasizing how each system interacts with the others and with external stimuli. The concepts of mitosis and meiosis are presented separately to establish that meiosis is a process of inheritance. Detailed anatomy of organs will be taught in high school Human Anatomy and Physiology, which extends the content of Life Science.

The second disciplinary core idea, “Ecosystems: Interactions, Systems, and Dynamics,” is a broad look at energy and ecosystem relationships that impact populations and environments. The third core idea, “Heredity: Inheritance and Variation of Traits,” focuses on inheritance of traits, variations, meiosis, and biotechnology as a foundation for the details of nucleotide structure, DNA replication, base-pairing, and protein synthesis, which will come in high school Biology. The fourth core idea, “Unity and Diversity,” illustrates classification of organisms and adaptations of organisms due to natural selection.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through guided participation in the engineering design process, students will address real-world problems by designing possible solutions to maintain biodiversity and ecosystem services.

Each content standard completes the stem *"**Students will**…"*

<table>
<tr><th colspan="3">From Molecules to Organisms: Structures and Processes</th></tr>
<tr><td rowspan="3">Cell Structure and Processes</td><td>1. Develop and use a model to explain the functions of specific cell structures necessary for maintaining a stable environment, including the cell membrane, cell wall, chloroplasts, endoplasmic reticulum, golgi apparatus, mitochondria, nucleus, ribosomes, and vacuoles.
a. Engage in argument from evidence to support claims of cell theory.
b. Construct an explanation of how prokaryotic and eukaryotic cells differ in structure and function.</td><td>Structure and Function</td></tr>
<tr><td>c. Plan and carry out an investigation to identify and explain features of a cell's semi-permeable membrane which enable it to control what enters and exits the cell.</td><td>Stability and Change</td></tr>
<tr><td>2. Construct an explanation of how photosynthesis and cellular respiration cycle matter and establish the flow of energy into and out of an organism.
a. Ask questions and construct an explanation of how anaerobic bacteria produce energy in environments with no oxygen.</td><td>Energy and Matter</td></tr>
<tr><td rowspan="3">Growth and Development</td><td>3. Construct an explanation of how the process of mitosis maintains complex organisms and ensures new cells with identical genetic information.</td><td>Structure and Function</td></tr>
<tr><td>a. Ask questions and communicate information regarding how errors in mitosis may affect cell division.
Example: formation of cancer cells</td><td>Cause and Effect</td></tr>
<tr><td>4. Obtain, evaluate, and communicate information explaining how cells, tissues, and organs of various systems of the human body work together for specific functions, including the circulatory, digestive, muscular, nervous, respiratory, and skeletal systems.
Examples: responding to stimuli, moving, breaking down, or transporting nutrients</td><td>Systems and System Models</td></tr>
</table>

<table>
<tr><th colspan="3">Ecosystems: Interactions, Energy, and Dynamics</th></tr>
<tr><td>Matter and Energy Flow</td><td>5. Construct an explanation of how the cycling of matter between abiotic and biotic parts of ecosystems demonstrates the flow of energy and the conservation of matter, including the carbon, nitrogen, and water cycles.</td><td>Energy and Matter</td></tr>
<tr><td>Population Dynamics</td><td>6. Analyze and interpret data to predict how environmental conditions, genetic factors, and resource availability will impact the growth of individual organisms and populations of organisms in an ecosystem.
Examples: location, population size, weather

7. Analyze and interpret data to explain how density-independent and density-dependent limiting factors in an ecosystem can lead to shifts in populations.
Examples: deforestation, disease, drought, fire, human activities, invasive species, succession</td><td rowspan="3">Cause and Effect</td></tr>
<tr><td>Interdependent Relationships</td><td>8. Construct an explanation that predicts patterns of interactions between and among organisms in different ecosystems.
Examples: competition, predation, mutualism, commensalism, parasitism</td></tr>
<tr><td>Biodiversity</td><td>9. Design a solution to maintain biodiversity and ecosystem services in a given scenario.
Examples: considering economic and social factors when making decisions about purifying water, recycling nutrients, preventing soil erosion, improving conditions for threatened and endangered species

10. Obtain, evaluate, and communicate information about characteristic animal behaviors and specialized plant structures and their effect on the probability of successful reproduction.
Examples: building nest to protect young from cold, flower characteristics that attract pollinators</td></tr>
</table>

Heredity: Inheritance and Variation of Traits		
Genetics and Biotechnology	11. Develop and use models to demonstrate how genetic variations between parents and offspring result from differences in inherited genes located on chromosomes. *Examples: monohybrid crosses using Punnett squares, homozygous and heterozygous allele pairs, phenotypes and genotypes, variants* 12. Develop and use models to explain how genes are expressed through the flow of genetic information from DNA to RNA to a functional protein. 13. Develop and use models to explain that meiosis results in new genetic combinations with increased variation. a. Construct an explanation of the advantages and disadvantages of asexual and sexual reproduction. *Examples: budding and binary fission occurring quickly, but with little variation; sexual reproduction requiring two organisms, but with increased variation* b. Construct an explanation from evidence of how genetic variants may result in harmful, beneficial, or neutral effects on the structure and function of an organism. 14. Obtain, evaluate, and communicate information on the use of technologies that impact the inheritance and appearance of traits in organisms. *Examples: genetic engineering, gene therapy, selective breeding, genetically modified organisms*	**Cause and Effect**

Unity and Diversity		
Phylogenetics	15. Analyze and interpret data from examination of fossils, relict species, and modern organisms to determine patterns of change in anatomical structures over time. *Example: Use a cladogram or phylogenetic tree.* 16. Obtain, evaluate, and communicate evidence comparing patterns in the embryological development of multiple species to identify relationships not evident in the fully formed adult anatomy. *Example: Use pictorial evidence of development of different species.*	**Patterns**
Natural Selection	17. Ask questions to clarify how natural selection over generations may lead to changes in the frequency of specific traits to enhance survival and reproduction of a population.	**Cause and Effect**

Grade 8
Physical Science

Grade 8 Physical Science is designed to help students apply physical science concepts to daily life, including electricity, thermal energy transfer, and the acceleration of objects such as a car. It also provides students with the skills and content knowledge necessary to be successful in high school chemistry, physics, and physical science courses. Physical Science requires comprehensive learning and the use of reading, writing, and mathematics skills.

This course focuses on four disciplinary core ideas from the physical sciences domain. In “Matter and Its Interactions,” students study the structure and function of matter and their effects on chemical reactions. In the second core idea, “Motion and Stability: Forces and Interactions,” students explore different forces and various types of interactions. They also engage in predicting and developing explanations for changes in motion. The “Energy” core idea involves the conservation of energy, energy transformations, and applications of energy to everyday life. In the final core idea, “Waves and Their Applications in Technologies for Information Transfer,” students examine the relationships between wave properties, types of signals, and their interactions with different instruments.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon. Through guided participation in the engineering design process, students design and test a device that can release or absorb thermal energy by chemical reactions and design, construct, and modify an electromagnet.

Each content standard completes the stem *“**Students will**…”*

Matter and Its Interactions		
Structure and Properties	1. Plan and carry out investigations to support the claim that pure substances can be described and defined by their properties, including solubility, electrical conductivity, and density.	**Structure and Function**
	2. Develop and manipulate models to explain changes in particle motion, temperature, and state of a pure substance when thermal energy is added to or removed from a system.	**Energy and Matter**

	3. Justify a claim, based on evidence from investigations, that pure substances differ from mixtures, including solutions.	**Structure and Function**
	4. Obtain and communicate information from the periodic table, including atomic number, number of electrons and neutrons, average atomic mass, groups, and periods, to illustrate the structure and composition of atoms of different elements. a. Analyze and interpret data to differentiate among elements based on their properties and classify the elements as metals, nonmetals, or metalloids.	**Patterns**
	5. Obtain, evaluate, and communicate information from the periodic table to make predictions about the reactivity of the main group elements. a. Use valence electron configuration to model ionic and covalent bonds.	**Structure and Function**
Chemical Reactions	6. Observe and analyze data regarding characteristic properties of substances before and after they are combined to determine whether a chemical reaction has occurred. *Examples: color change, temperature change, production of a gas, formation of a precipitate*	**Stability and Change**
	7. Analyze data from an investigation to determine whether thermal energy is released or absorbed in a chemical reaction. a. Design and test a device that can release or absorb thermal energy by chemical reactions. 8. Engage in an argument from evidence to support the claim that matter is conserved in a chemical reaction. a. Use a model to verify that atoms of reactants are conserved as products in a chemical reaction. *Examples: simulations, atomic and molecular drawings, or equations to compare atoms in the reactants and products*	**Energy and Matter**

Motion and Stability: Forces and Interactions		
Forces and Motion	9. Use data from an investigation to identify factors that affect acceleration. *Examples: velocity vs. time graphs, data tables, diagrams* 10. Develop and use models to illustrate how individual external forces affect the motion of objects. *Examples: frictional forces, gravitational force, applied forces* 11. Use models to demonstrate each of Newton's laws of motion and explain the effect of net force on objects. *Examples: A model car on a table remains at rest until pushed, and a marble rolls across the floor until friction causes it to stop (first law of inertia); a bicycle rider's leg muscles apply force to the mass of the bicycle, causing the bicycle to move, and greater acceleration results when pedaling harder creates a greater net force (second law); a ball hitting the ground applies downward action force and the ground applies an upward reaction force, causing the ball to bounce (third law).* a. Use mathematical representations to explain how the sum of external forces on an object and the object's mass affect its acceleration. *Examples: data tables, graphs, diagrams* 12. Use a model to identify factors affecting the strength of noncontact forces, including magnetic, gravitational, and electrical forces, and demonstrate that fields exist even though the objects are not in contact. a. ⚙Design and construct an electromagnet and modify the design to change its strength.	**Cause and Effect**

Energy		
Types of Energy	13. Analyze graphical displays of data to describe the relationship of mass and velocity of an object to its kinetic energy (KE). *Examples: mass vs. KE graph, velocity vs. KE graph, data table*	**Scale, Proportion, and Quantity**

	14. Use models to construct an explanation of how a system of objects may contain varying amounts of potential energy, including gravitational, elastic, and chemical.	**Systems and System Models**
Conservation of Energy	15. Use models to construct an explanation of how energy is transformed but still conserved. *Example: kinetic energy to potential energy* 16. Develop and use a model to construct an explanation of how electrical energy is transferred and transformed. *Example: In a circuit, there is an energy source (battery) that has chemical potential energy. Chemical energy is transformed into electrical energy (current), transferred through the wires, and transformed again into light and heat in the light bulb. Add a resistor and analyze its effect on current.*	
Waves and Their Applications in Technologies for Information Transfer		
Wave Properties	17. Use models of mechanical and electromagnetic waves to qualitatively describe the relationships among wave properties, including amplitude, wavelength, and frequency. *Example: Use a model to show that frequency and wavelength are inversely proportional.* a. Use models to compare and contrast light and sound wave behaviors, including reflection, refraction, diffraction, and speed, as waves propagate and interact with matter.	**Scale, Proportion, and Quantity**
Information Transfer	18. Construct an argument from evidence that digital and analog signals encode and transmit information differently.	

Grades 9-12 Overview

The high school science standards provide essential preparation for academic and career success for all students in Grades 9-12. The courses are designed to enable students to understand the disciplinary core ideas by engaging in science and engineering practices. Students will build upon content knowledge from the middle grades through increased rigor and complexity to deepen their understanding of science. High school graduates should have an adequate scientific background to be active, informed citizens and to succeed in both the workplace and postsecondary courses.

High school science courses continue to build and enhance scientific literacy. To be scientifically literate, students should have the ability to formulate and pose scientific inquiries that establish what is known and what still needs to be understood. They should be able to conduct investigations based on well-developed hypotheses, construct models that demonstrate abstract concepts, and use appropriate tools to obtain numerical measurements that explain mathematical relationships. Additionally, students should formulate explanations of scientific phenomena using academic language, and be able to apply problem-solving skills to create innovative solutions. Finally, students should be able to obtain, assess, and communicate knowledge from scientific literature and construct and engage in evidence-based arguments.

The standards are designed to empower educators to present content in ways that inspire students to be inquisitive, take initiative to investigate, and critically engage with scientific content. The instructional environment of the science classroom should be student-centered, collaborative, and inquiry-based. All science courses in Grades 9-12 should include a laboratory-based component that encourages students to apply investigation and reasoning skills to develop explanations and propose solutions. Conceptual learning should be supported by computational and graphical representations, and students should be able to apply data analysis techniques and demonstrate mathematical thinking. Specific scientific practices are included in course overviews.

Science and Engineering Practices

Science and engineering practices (SEPs) help students understand the development of scientific knowledge, the work of engineers, and the connections between them. When students are given opportunities to engage in these practices, they are able to expand, strengthen, and apply their knowledge of core ideas and crosscutting concepts. Students can use SEPs in any order to explore the many applications of science and the disciplines of engineering.

SEPs encapsulate essential dimensions of science learning. They outline what students should be doing as they study science, and proficiency with these practices is critical. The SEPs are identified and explained at the beginning of each grade band and are to be incorporated across all grades. Each SEP builds on related experiences in previous grades and progresses to increasingly complex applications.

For example, *Constructing Explanations and Designing Solutions* in Grades 6-8 focused on "constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories." In Grades 9-12, the practice sets out criteria for acceptable types of evidence: "developing explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories."

The chart below highlights how the SEPs are utilized in Grades 9-12, and can answer the question, "What are students doing when they engage in this practice in this grade band?"

Science and Engineering Practices (SEPs) Grades 9-12 SEPs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.*	
Asking Questions and Defining Problems	Formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.
Developing and Using Models	Using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).
Planning and Carrying Out Investigations	Designing and conducting investigations that test and provide evidence for conceptual, mathematical, physical, and empirical models.
Analyzing and Interpreting Data	Introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of graphs and models to generate and analyze data.
Using Mathematics and Computational Thinking	Using algebraic thinking and analysis, a range of linear and nonlinear functions (including trigonometric functions, exponentials and logarithms), and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
Constructing Explanations and Designing Solutions	Constructing explanations and designs that are supported by multiple, independent, student-generated sources of evidence consistent with scientific ideas, principles, and theories.
Engaging in Argument from Evidence	Using appropriate, sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current or historical episodes in science.
Obtaining, Evaluating, and Communicating Information	Evaluating the validity and reliability of claims, methods, and designs.

Crosscutting Concepts

Crosscutting concepts (CCCs) are ideas that pertain to all domains of science and link the domains together. They are essential elements for interconnecting knowledge from different fields into a coherent and scientifically-based understanding of the natural world. The knowledge framework provided by CCCs allows students to connect their prior experiences with newly-acquired knowledge of science and engineering to develop a broad conception of the workings of science. Crosscutting concepts are one of the three dimensions included in each standard, along with disciplinary core ideas and science and engineering practices, and explicit instruction on these common themes should be included in all grade bands and content areas. The chart at the beginning of each grade band indicates how each crosscutting concept is expressed in the grades of that band.

Crosscutting Concepts (CCCs) **Grades 9-12** **CCCs are taken from *The NSTA Quick Reference Guide to the Three Dimensions.***	
Patterns	Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced, thus requiring improved investigations and experiments. Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. Mathematical representations are needed to identify some patterns. Empirical evidence is needed to identify patterns.
Cause and Effect: Mechanism and Prediction	Empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller-scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity	The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can be studied only indirectly as they are too small, too large, too fast, or too slow for direct observation. Patterns observable at one scale may not be observable or exist at other scales. Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Systems and System Models	Systems can be designed to do specific tasks. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions (including energy, matter, and information flows) within and between systems at different scales. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.
Energy and Matter: Flows, Cycles, and Conservation	The total amount of energy and matter in closed systems is conserved. Changes of energy and matter in a system can be described in terms of the flow of energy and matter into, out of, and within that system. Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.
Structure and Function	Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal the structure's function and/or solve a problem. The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.
Stability and Change	Much of science deals with constructing explanations of how things change and how they remain stable. Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. Feedback (negative or positive) can stabilize or destabilize a system. Systems can be designed for greater or lesser stability.

Biology

Biology is an inquiry-based course focused on providing all high school students with foundational life science content about the patterns, processes, and interactions among living organisms. It emphasizes depth and detail in a limited number of core ideas rather than memorization of broad factual content.

Each standard's foundational knowledge is integrated with the science and engineering practices to provide students with opportunities to engage in scientific inquiry. Students use both new and prior knowledge to build conceptual understandings based on evidence from their own and others' investigations. They use their own learning and experiences to support claims and engage in argument from evidence and to produce innovative solutions that reflect how scientists formulate explanations.

The standards provide opportunities to create deeper conceptual understanding and foster scientific literacy for college, career, and citizenship. Resources specific to the local area, scholarly resources (including evidenced-based literature from scientific journals, real-world data, industry studies, and scientific reports), and laboratory investigations should be used to extend and increase the complexity of the core ideas.

The Biology course incorporates safe laboratory investigations where students can actively explore the aspects of living things. Students are encouraged to apply evidence-based reasoning to investigate various structures, processes, and interactions in organisms. Hands-on experiences in the lab spark curiosity and build interest in learning about living things and are especially valuable for students interested in biology-related science, technology, engineering, and mathematics (STEM) careers.

Content standards within this course are organized according to the disciplinary core ideas for the life sciences domain. The first core idea, "From Molecules to Organisms: Structures and Processes," emphasizes the structure of cells and how their functions are necessary for supporting life, growth, behavior, and reproduction. The second core idea, "Ecosystems: Interactions, Energy, and Dynamics," investigates the positive and negative interactions between living organisms and other biotic and abiotic factors, as well as investigating and celebrating Alabama's biodiversity.

The third core idea, "Heredity: Inheritance and Variation of Traits," centers on the formation of proteins that affect trait expression (also known as the central dogma of molecular biology); the passing of genetic information through generations; and how environmental factors and errors in DNA replication can contribute to genetic variation. The fourth core idea, "Unity and Diversity," examines the variation of traits within a population that results in diversity among organisms over a long period of time. This core idea also focuses on analyzing the relatedness between organisms and groups of organisms using phylogenetic trees and cladograms. This approach moves away from the shifting nomenclature in hierarchical taxonomies toward the use of technologies to determine species relatedness.

Each content standard completes the stem *"**Students will**…"*

<table>
<tr><th colspan="3">From Molecules to Organisms: Structures and Processes</th></tr>
<tr><td>Cells</td><td>1. Engage in evidence-based argument to relate a cell's function to the structure, function, and diversity of its components.
Examples: Muscle cells have a large number of mitochondria, which create energy for contraction in the form of ATP. Some plant cells have a large vacuole which is used for storage and transport of excess nutrients in changing environments.</td><td rowspan="2">Structure and Function</td></tr>
<tr><td>DNA and Protein Synthesis</td><td>2. Obtain and evaluate information to explain the role of DNA and RNA in transcription and translation leading to protein synthesis and cellular function.
a. Use a model to describe the structure and sequence of DNA, including nucleotide structure, base pairing, and the structure of the helix.
b. Obtain and evaluate information to explore additional functions and regulatory roles of RNA, DNA, and protein, including their roles in gene expression and cellular differentiation.
Examples: RNA contributing to ribosome structure, histone modification altering chromatin structure, and transcription factors and non-coding DNA involved in nuclear regulatory functions
Clarification: Discussion should include proteins that regulate and carry out essential functions of life including enzymes, structural proteins, hormones, and receptors.
c. Obtain, evaluate, and communicate information regarding how DNA and genetic technology apply to daily life.
Examples: CRISPR can be used to develop species-specific pest control tools. GMO technology is used to produce drought-resistant plants to increase food supplies. Genetic screening is used in neonatal healthcare.</td></tr>
</table>

Growth and Development	3. Develop and use models to explain how events during the cell cycle lead to the formation of new cells and repair of multicellular organisms, including cell growth, DNA replication, separation of chromosomes, and separation of cell contents. a. Construct an explanation of the process of DNA replication during cellular division (S-phase). b. Using observations of cell growth, construct an explanation of how the cell cycle leads to differentiation in tissue development. *Examples: stages of cellular differentiation that lead to formation of tissues in embryological development, dysfunction in the cell cycle that leads to uncontrolled cell growth (cancers and tumor growth), exposure to external stimuli that leads to changes in plant tissue growth or plant tropisms (phototropism, gravitropism)*	**Systems and System Models**
Cellular Homeostasis	4. Engage in argument from evidence to explain the regulation of cellular processes that maintain homeostasis, including active and passive transport. *Examples: evidence from a laboratory exercise investigating the effects of various factors such as temperature and concentration gradient on diffusion; viewing simulations of active transport and arguing its role in urine formation.* a. Use models to illustrate how the structural characteristics of lipids and proteins in the cell membrane regulate cellular processes. b. Construct an explanation of how the unique properties of water are vital to maintaining homeostasis in organisms. *Examples: Explain how cohesive properties contribute to capillary action and the movement of water in plants, how water is the universal solvent, and that the heat capacity of water contributes to survival in extreme habitats.*	**Structure and Function**

Photosynthesis and Respiration	5. Plan and carry out investigations and utilize results to explain the role and cycling of products and reactants involved in the cellular conversion of energy. a. Construct an explanation of how the structural characteristics of carbohydrates and lipids store energy. b. Use models of the reactants and products of photosynthesis to illustrate the conversion of light energy into stored chemical energy within cells. *Examples: diagrams, flow charts, chemical equations, interactive games, concept maps* **Clarification: Steps of light reactions, the Calvin cycle, or chemical structures of molecules are not required.** c. Use models of the reactants and products of cellular respiration (both aerobic and anaerobic) to illustrate how chemical energy is stored in the bonds of carbohydrates and lipids and converted to ATP and heat when the bonds are broken. *Examples: diagrams, chemical equations, conceptual models* **Clarification: Identification of the steps or specific process involved in cellular respiration or specific types of fermentation is not required.**	**Energy and Matter**
Ecosystems: Interactions, Energy, and Dynamics		
Interdependent Relationships	6. Develop and use models to illustrate interactions between ecological hierarchy levels, including biosphere, biome, ecosystem, community, population, and organism.	**Systems and System Models**
Matter and Energy Flow	7. Develop and use models to illustrate the flow of matter and energy between abiotic and biotic factors in ecosystems, including loss of heat, 10% rule, and the conservation of matter. *Examples: Diagram biogeochemical cycles (C, N, P, S), food chains, food webs, or biomass pyramids to illustrate the movement of energy and the conservation of matter.* **Clarification: Steps of the biogeochemical cycles are not required. The focus of the standard is to create awareness of the importance of the exchange of elements between the subsystems.**	

Population Dynamics	8. Construct an evidence-based explanation of how density-dependent and density-independent factors affect population growth. *Examples: Utilize calculated averages, trends, or graphical comparisons of multiple sets of data detailing exponential, linear, or logistic growth to explain how food shortage decreases the population of animals in a particular habitat.*	**Scale, Proportion, and Quantity**
Biodiversity	9. Obtain, evaluate, and communicate data to explain how the biodiversity of Alabama contributes to ecosystem services in the state. *Examples: Alabama has many species of freshwater fish, which support a robust fishery. Alabama's extensive, diverse forests support the timber industry.* a. Obtain and evaluate data to describe human impact on various Alabama ecosystems. *Examples: Explain how nitrogen runoff from farms affects algal growth in Mobile Bay. Explain how invasive species (such as kudzu or cogon grass) affect Alabama ecosystems. Explain the impact of building on top of sand dunes on barrier islands along the Gulf Coast. Explain how humans have introduced white nose syndrome into bat cave habitat.*	
	10. Engage in argument from evidence to support the claim that characteristics of an ecosystem contribute to its resilience and stability, including ecological succession and recovery from disturbance. *Examples: Gather evidence that fire suppression impacts seed germination in fire-dependent ecosystems. Using evidence from biodiversity indices, support the claim that biodiversity contributes to functional redundancy in tropical rainforests.*	**Stability and Change**

Heredity: Inheritance and Variation of Traits		
Inherited Traits and Environmental Impact	11. Use probability and statistical models to explain the variation of expressed traits within a population. *Examples: pedigree charts, family and population studies*	**Patterns**
	a. Use mathematics and computational thinking to predict patterns of inheritance, including dominance, recessiveness, codominance, and incomplete dominance. *Examples: Use a Punnett square to illustrate codominance in genes for blood types. Use probability rules to predict the phenotypes of offspring from different parental combinations.* b. Obtain, evaluate, and communicate information about how the interplay of heritable risk factors, somatic mutations, and environment influences human disease. *Examples: Because heart disease has heritable and environmental risk factors, a person's total risk needs to include both factors. Cancers have both heritable (breast, lung, colorectal, skin, cervical cancer) and environmental risk factors (smoking, diet, sun exposure, HPV exposure).* **Clarification: Epigenetics could be an extension of this standard.**	**Systems and System Models**
Heredity and Meiosis	12. Develop and use an evidence-based model to illustrate the formation of reproductive cells through the process of meiosis. *Example: Use karyotype cutouts to illustrate independent assortment into reproductive cells.*	**Systems and System Models**
	a. Construct an explanation of how new genetic combinations and variations occur during crossover. b. Obtain, evaluate, and communicate information about how errors during meiosis and environmental factors affect the expression of traits. *Examples: Translocation between chromosomes 8 and 11 can cause myeloproliferative disorder and lymphoma. Smoking and exposure to teratogenic chemicals can alter genes in reproductive cells that can be passed on to offspring.*	**Cause and Effect**

<table>
<tr><th colspan="3">Unity and Diversity</th></tr>
<tr><td>Phylogenetics</td><td>13. Analyze and interpret data to support hypotheses of common ancestry and biological evolution illustrated by cladograms and phylogenetic trees.
Examples: Use cladograms and phylogenetic trees developed from evidence (such as fossil records, comparative anatomy, comparative embryology, biogeography, or DNA/RNA/amino acids sequences) to discuss common ancestry and biological evolution.
Clarification: Emphasis is on students' conceptual understanding of how lines of evidence relate to common ancestry and biological evolution, and is not extended to the lines of evidence for specific species.
a. Evaluate evidence supporting claims that viruses should be placed in a separate category from living things.</td><td>Patterns</td></tr>
<tr><td rowspan="2">Natural Selection</td><td>14. Analyze and interpret data pertaining to adaptations resulting from natural and artificial selection to explain the evolution of populations.
Examples: number of antibiotic-resistant bacteria present after incremental exposure to antibiotics, frequency distribution of different colored moths before and after the Industrial Revolution, population counts of tuskless elephants before and after poaching, frequency distribution of mutations resulting from errors in DNA replication leading to new alleles present in the population
Clarification: This standard should focus on using evidence to explain how types of selection influences the number of organisms and behaviors, morphology, or physiology of species. Other mechanisms of evolution, such as genetic drift, gene flow through migration, and co-evolution, are not required.</td><td>Stability and Change</td></tr>
<tr><td>15. Engage in argument from evidence to explain how populations respond to changes in the environment that can lead to speciation or extinction.
Examples: emergence of geographic barriers over time leading to speciation; large-scale climate change shifting weather patterns and driving speciation or extinction; global disasters such as asteroids and volcanos leading to mass extinction events; anthropogenic shifts in climate or habitat causing extinction
Clarification: Discussion of allele frequency calculations is not required.</td><td>Cause and Effect</td></tr>
</table>

Chemistry

Chemistry is a physical science course that focuses on the properties and behavior of matter. The concepts explored in chemistry are fundamental to understanding all areas of science and the components of the universe at both the microscopic and macroscopic levels. Chemistry encompasses both qualitative and quantitative analysis of scientific processes, supported by inquiry-based learning and laboratory experiences.

In Chemistry, students use the academic language of science in context to communicate claims, evidence, and reasoning for chemical phenomena. The course provides in-depth investigations of the properties and interactions of matter, allowing students to acquire prerequisite skills for postsecondary studies and careers in science, technology, engineering, and mathematics (STEM) fields. External resources, including evidence-based research published in scientific journals, should be utilized to provide students with a broad scientific experience which will adequately prepare them for college, careers, and citizenship.

Content standards within this course are organized according to three of the disciplinary core ideas for physical science. The first core idea, "Matter and Its Interactions," deals with the substances and processes encompassing our universe on microscopic and macroscopic levels. The second core idea, "Motion and Stability: Forces and Interactions," concentrates on forces and motion, types of interactions, and stability and instability in chemical systems. The third core idea, "Energy," involves conserving energy, energy transformations, and energy applications to everyday life.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through guided participation in the engineering design process, students will design and conduct experiments to evaluate the effect of solute concentration on the colligative properties of a solution.

Although not included as discrete standards, these scientific practices should be embedded throughout the course:

- Measurement - Choose appropriate tools and record measurements with the correct number of significant figures to show measured and estimated digits and units.
- Significant figures - Record the correct number of significant figures after performing mathematical calculations with the data.
- Dimensional analysis - Perform unit conversions using dimensional analysis, including conversions of derived units such as g/cm^3 and molar conversions.
- Scientific notation - Use scientific notation to report very large or small quantities with the correct number of significant figures, and carry out multiplication, division, addition, and subtraction calculations with scientific notation.
- Graphing - Create graphs to determine and communicate relationships between variables and analyze graphs to make predictions about unknown data points.

Each content standard completes the stem *"**Students will**…"*

Matter and Its Interactions		
Structure and Properties	1. Use the periodic table as a model to predict the structure and properties of atoms and elements.	**Patterns**
	a. Assess the merits and limitations of historic and modern atomic models pertaining to the presence, position, mass, and charge of subatomic particles. b. Develop and use models of an element's subatomic particles to compare and contrast its atoms, ions, and isotopes.	**Structure and Function**
	c. Analyze and interpret data to identify or describe an element based on its number of protons, its relative abundance of isotopes, its organization and placement of electrons, and its light emission spectrum. *Examples: average atomic mass, electron configuration, orbital notation, noble-gas notation, photoemission spectroscopy*	**Cause and Effect**
	d. Ask questions to determine the relationship between an element's physical and chemical properties and its position on the periodic table. *Examples: density, melting point, chemical hardness*; *reactivity, chemical stability, oxidation state* e. Construct explanations of how periodic trends can be used to predict the properties of elements. *Examples: atomic radii, ionization energy, electronegativity*	**Patterns**

Motion and Stability: Forces and Interactions		
Atomic and Molecular Interactions	2. Construct explanations of the formation of intramolecular and intermolecular forces and their effects on atomic and molecular interactions.	**Structure and Function**
	a. Develop and use Lewis dot diagrams to model the formation of covalent and ionic bonds.	**Systems and System Models**
	b. Construct an explanation of the change in potential energy that occurs when chemical bonds are formed.	**Cause and Effect**
	c. Plan and carry out an investigation to identify specific physical and chemical properties of compounds formed from ionic, covalent, and metallic bonding. *Examples: melting point, boiling point, density, solubility, state of matter, electrical conductivity; flammability, toxicity*	**Scale, Proportion, and Quantity**
	d. Develop and use models based on valence shell electron pair repulsion (VSEPR) theory to predict the shape of a molecule up to four electron domains around the central atom.	**Systems and System Models**
	e. Construct an explanation of the polarity of a molecule based on electronegativity data and molecular geometry. f. Analyze and interpret data from the periodic table to derive chemical formulas and names for ionic and covalent compounds.	**Patterns**
	g. Analyze and interpret data to compare the strengths of intermolecular forces and to explain how these forces affect physical properties. *Examples: dipole-dipole interactions, hydrogen bonding, London dispersion forces*	**Structure and Function**

Matter and Its Interactions: Energy		
Chemical Reactions	3. Develop and use multiple types of models to represent chemical reactions.	**Systems and System Models**
	a. Use qualitative and quantitative reasoning to describe and balance chemical equations to satisfy the law of conservation of matter. *Examples: describe differences in properties of reactants and products*	**Scale, Proportion, and Quantity**
	b. Use qualitative and quantitative reasoning to classify chemical reactions, predict the products of single replacement and double replacement reactions, and represent chemical reactions using ionic equations.	**Patterns**
	c. Analyze and interpret temperature and bond energy data to classify a reaction as endothermic or exothermic.	**Energy and Matter**
	d. Construct an explanation, using particle diagrams and collision theory, for how particle size, concentration, and temperature affect the rate of a chemical reaction.	**Stability and Change**

Matter and Its Interactions		
Stoichiometry	4. Use stoichiometric ratios to support the claim that atoms, and therefore mass, are conserved during chemical reactions. a. Quantitatively apply the concepts of the mole and Avogadro's number to conceptualize and calculate percent composition and empirical or molecular formulas of common compounds. b. Use mathematical representations of the mole concept to solve reaction stoichiometry problems, involving mole-to-mole conversions, mass-to-mole conversions, and mass-to-mass conversions.	**Scale, Proportion, and Quantity**

	c. Use mathematical models to reveal the relationships among the theoretical, actual, and percent yields of chemical reactions. d. Qualitatively and quantitatively determine the limiting reactant when given the masses of all reactants. e. Use mathematics and computational thinking to perform gas stoichiometry calculations involving mass, volume, and number of moles at standard temperature and pressure (STP).	
Solutions	5. Obtain, evaluate, and communicate information concerning factors that affect solubility and the properties of solutions. a. Use mathematics and computational thinking to express the concentrations of given solutions in terms of molarity and molality.	
	b. Develop and use models to illustrate solute-solvent interactions. *Example: particle diagram*	**Structure and Function**
	c. Use mathematics and computational thinking to prepare solutions from both solids and concentrated solutions when given a desired molarity and volume.	**Scale, Proportion, and Quantity**
	d. Analyze and interpret data to explain the effects of temperature on the solubility of solid, liquid, and gaseous solutes in a solvent and the effects of pressure on the solubility of gaseous solutes. e. Design and conduct experiments to evaluate the effect of solute concentration on the colligative properties of a solution. *Examples: boiling point, freezing point, vapor pressure*	**Cause and Effect**
Acids and Bases	6. Make qualitative and quantitative claims, based on ion concentration, about the acidic, basic, or neutral characteristics of a solution. a. Obtain, evaluate, and communicate information concerning the properties of acids and bases. b. Use the periodic table and computational thinking to derive chemical formulas and names of acids and bases.	**Patterns**

	c. Use multiple models to predict the relative properties of strong, weak, concentrated, and dilute acids and bases. *Examples: Arrhenius and Brønsted-Lowry acids and bases*	**Structure and Function**
	d. Use mathematics to calculate the pH, pOH, $[OH^-]$, and $[H_3O^+]$ of common solutions. e. Plan and carry out a strong acid-strong base titration to determine the concentration of an unknown acidic or basic solution.	**Scale, Proportion, and Quantity**
	Energy	
Gases	7. Plan and carry out investigations to determine how the atomic and molecular motion in chemical and physical processes is related to the kinetic molecular theory. a. Qualitatively and quantitatively relate changes in the temperature and pressure of a gas to particle motion and number of collisions. b. Express the relationship among pressure, volume, temperature, and the number of moles of a gas quantitatively, conceptually, and graphically. *Examples: Boyle's Law, Charles's Law, Dalton's Law of Partial Pressures, Ideal Gas Law*	**Cause and Effect**

Earth and Space Science

Earth and Space Science is based on the Earth and space science domain, with content focused on our ever-changing planet and its weather, Earth's place in the universe, and the integration of its constantly evolving systems. Content also includes historical perspectives on the universe and Alabama's contributions to space exploration. Earth and Space Science is strongly recommended for all high school students.

The course is based on two disciplinary core ideas in the earth and space science domain. The first core idea, "Earth's Place in the Universe," addresses stars and star properties, the solar system and the universe, and historical astronomical perspectives. The second core idea, "Earth's Systems," examines the composition and history of the Earth, plate tectonics, weather, climate, and severe weather.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems.

Teachers are encouraged to incorporate current, relevant information from scientific literature and draw upon local resources to engage students and extend the disciplinary core ideas. Standards are written so students can access and expand upon prior knowledge, incorporate personal experiences, and integrate new learning to build conceptual understanding. The content standards foster scientific, mathematical, and graphical literacy to prepare students for post-secondary study, careers, and citizenship.

Although not included as discrete standards, these practices should be embedded throughout each unit:

- Measurement - Choose appropriate tools and record measurements with the correct units.
- Mathematics - Calculate ratios, rates, percentages, and unit conversions to represent and solve scientific and engineering problems.
- Graphic literacy- Read, analyze, and interpret graphs, charts, and tables to address a scientific question or solve a problem.

Each content standard completes the stem *"Students will…"*

Earth's Place in the Universe		
Stars and Star Properties	1. Obtain, evaluate, and communicate information about the connections among mass, gravity, and fusion in the life cycle of stars.	**Patterns**
	a. Utilize models to explain the process of stellar evolution from star birth to star death.	**Stability and Change**
	b. Interpret the Hertzsprung-Russell diagram to analyze the properties of stars, including density, magnitude, temperature, rates of fusion, and spectral class.	**Systems and System Models**
	c. Obtain, evaluate, and communicate information about how nuclear fusion in stars and supernovas leads to the formation of all other elements.	**Cause and Effect**
	d. Analyze and interpret data to quantify the energy produced in stars, using Einstein's theory of general relativity by applying $E=mc^2$ to show that the small amount of mass produced during hydrogen fusion produces a large amount of energy.	**Energy and Matter**
The Solar System and the Universe	2. Obtain, evaluate, and communicate information about the structure and motion of components of the universe and solar system. a. Use mathematics and computational thinking to predict the motion of natural and man-made objects in the solar system, using Kepler's laws, Newton's laws of motion, and Newton's gravitational laws. b. Use mathematics and computational thinking to explain the relationships between the properties of light and distances in the solar system and universe, including the Doppler effect, red shift, light years, and astronomical units.	**Cause and Effect**

	c. Analyze spectroscopic data to determine the properties and motion of objects in space. *Example: Use spectral lines to identify unknown elements in stars. Use a blackbody curve to determine the temperature of objects in space.*	**Patterns**
	d. Investigate and communicate major properties of bodies in the solar system and the zones they inhabit. *Examples: planets, dwarf planets, major moons, asteroid belt, comets, the Kuiper belt, the Öort cloud*	**Structure and Function**
	e. Use mathematics to explain how solar intensity and the tilt of the Earth's axis impact the distribution of sunlight on the Earth's surface, including zenith angle, solar angle, and surface area.	**Patterns**
Historical Perspectives	3. Research, evaluate, and communicate information about how the findings of early astronomers, including Aristotle, Ptolemy, Copernicus, Galileo, Brahe, Kepler, Newton, and Einstein, challenged the thinking of their time, allowed for academic advancements, and built a foundation for space exploration. *Examples: Ptolemy supported a geocentric solar system with fixed stars, circular orbits of planets, and a perfect and unchanging universe. Kepler supported a heliocentric solar system, elliptical orbits of planets, and a changing universe; his laws predict the motions of satellites.* a. Obtain and evaluate scientific information that explains how the application of new knowledge and technological advances has improved human understanding of the universe. *Examples: Annie Cannon designed a star classification system based on star color and temperature that is still used today. Edwin Hubble used Christian Doppler's research to determine redshift. Robert Wilson and Arno Penzias discovered Cosmic Background Radiation, providing evidence for an expanding universe. Stephen Hawking and Neil deGrasse Tyson made astronomy more accessible to the public.*	**Cause and Effect**

	b. Construct an evidence-based explanation of the connections among various cosmic phenomena, citing leading scientific theories.	**Energy and Matter**
	c. Obtain and communicate information about Alabama's contributions to space exploration.	**Cause and Effect**
	Earth's Systems	
Composition of the Earth	4. Obtain, evaluate, and communicate information about the geologic conditions and processes that form different Earth materials. a. Plan and carry out investigations to explore the processes that form plutonic (intrusive) and volcanic (extrusive) igneous rocks of differing compositions and textures. *Example: Conduct a crystallization experiment to determine how speed of cooling affects crystal size.*	**Energy and Matter**
	b. Analyze and interpret data to explain the effects of mechanical and chemical weathering and erosion on Earth's materials by wind, water, ice, and gravity. c. Construct an explanation using evidence from experiments, models, or data of the processes that create and transform igneous, sedimentary, and metamorphic rocks. d. Plan and conduct an investigation on water's effect on surface and subsurface processes. *Examples: Use particles of varying sizes to determine how the speed of water impacts particle distribution. Use the porosity and permeability of particles of various sizes to determine how the size and sorting of particles affects water movement.* e. Obtain and communicate information about significant geologic characteristics in Alabama and the southeastern United States. *Examples: types of rocks, caves, sinkholes, minerals, energy resources*	**Cause and Effect**

Earth's History	5. Obtain, evaluate, and communicate information about major events in Earth's history. a. Analyze and interpret data to sequence events in Earth's history, including relative and absolute dating techniques, principles of superposition and crosscutting relationships, igneous intrusions, radiometric dating, and the fossil record.	**Patterns**
	b. Construct an explanation based on evidence of how catastrophic and long-term events have impacted life on Earth, including mass extinctions. c. Construct explanations from evidence of how the flow of energy through Earth's systems has changed over time. *Example: Earth's oxygen level was lowest during the Cryptozoic Eon (Precambrian) and highest in the Carboniferous.* d. Obtain, evaluate, and communicate information about important tectonic and geologic events that have occurred in Alabama over geologic time. *Examples: geologic ages and types of rocks, fluctuations in sea levels, temperature changes*	**Cause and Effect**
Plate Tectonics	6. Obtain, evaluate, and communicate information about the theory of plate tectonics.	**Patterns**
	a. Construct an evidence-based explanation of continental drift, basing conclusions on comparisons of coastlines, fossils, ages of rocks, climate, and magnetic patterns. b. Construct an explanation, based on evidence, of tectonic plate movement, types of plate boundaries, and how boundary type relates to specific tectonic features, including mountain ranges, earthquakes, volcanism, volcanic islands, hotspots, mid-ocean ridges, and faults.	**Stability and Change**
	c. Develop and interpret a model of Earth's internal structure and composition, including inner core, outer core, asthenosphere, lithosphere, mantle, and crust.	**Systems and System Models**

	d. Analyze data to interpret seismic activity and assess the risk of volcanic eruptions and earthquakes in Alabama and other areas in the United States.	**Cause and Effect**
Weather	7. Obtain, evaluate, and communicate information about the role of energy transfer in wind, precipitation, cloud formation, and front formation. a. Obtain and communicate information to explain how water cycles through the atmosphere, including condensation, evaporation, clouds, types of precipitation, relative humidity, and dew point.	
	b. Plan and carry out an investigation to determine the differential heating of land and water and explain how these differences create changes in local and global weather. *Example: Heat water and soil under lamps for 10 minutes and allow water and soil to cool for 10 minutes, then apply the results to explain land and sea breezes.* c. Construct an explanation of how air masses, source regions, fronts, weather changes associated with frontal passage (including cold, warm, occluded, and stationary fronts), air pressure, air density, temperature, cloud types, and precipitation are related to each other. d. Use data to construct an explanation of the role of pressure differences in the development of wind systems. *Examples: Analyze high and low pressure centers to determine direction of air motion. Calculate pressure gradients to determine the direction of air motion.*	**Systems and System Models**
	e. Analyze and interpret data to create a surface map, including high-pressure and low-pressure systems, isobars, wind barbs, cloud types, precipitation, and fronts.	**Stability and Change**

Climate and Severe Weather	8. Obtain and communicate information to explain different climate regions and their impact on patterns of severe weather. a. Analyze temperature and precipitation patterns related to factors that influence climate, including proximity to water, topography, elevation, latitude, and orographic effect. b. Analyze and interpret data to develop predictions about the formation of meteorological events. *Examples: severe thunderstorms, hurricanes, tornadoes, floods, droughts, winter storms* c. Communicate scientific information to explain the personal, local, and statewide implications of severe weather events in Alabama.	**Cause and Effect**

Environmental Science

Environmental Science introduces students to a broad view of the biosphere and the physical attributes that affect it. The standards include the study of ecosystems and natural resources, human impacts on Earth's systems, and changing patterns of weather and climate. Environmental Science provides a "deep dive" into the ways systems interconnect, interact, and influence events over long and short periods of time.

Students are challenged to evaluate and synthesize current findings from multiple sources of reliable, scholarly information to address issues or suggest possible solutions for environmental problems. The Environmental Science course incorporates safe laboratory investigations that enable students actively to explore the environment. Students are encouraged to apply evidence-based reasoning to investigate how Earth's systems interact with biotic, abiotic, and anthropogenic influences. Hands-on experiences in the lab spark curiosity and build interest in learning about the environment. These hands-on experiences are especially valuable for students interested in science, technology, engineering, and mathematics (STEM) careers related to environmental science. Although environmental legislation is not included in the standards, the exploration and application of these laws and policies can be an extension of learning environmental science.

The disciplinary core ideas in Environmental Science are "Ecosystems: Interactions, Energy, and Dynamics," "Unity and Diversity," "Earth's Systems," and "Earth and Human Activity." The academic language of core ideas is used in context to communicate claims, evidence, and reasoning for phenomena and to engage in argument from evidence to justify and defend claims.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through participation in the engineering design process, students will evaluate and refine a current solution designed to protect natural resources and design and defend a sustainability plan to reduce an individual's ecological footprint.

Although not included as discrete standards, these practices should be embedded throughout each unit:

- Measurement - Choose appropriate measurement tools and record measurements with the correct units.
- Mathematics - Calculate ratios, rates, percentages, and unit conversions to represent and solve scientific and engineering problems.
- Graphic literacy - Read, analyze, and interpret graphs, charts, and tables to address a scientific question or solve a problem.

Each content standard completes the stem *"**Students will**…"*

Ecosystems: Interactions, Energy, and Dynamics		
Matter and Energy Flow	1. Use mathematical representations to illustrate how the first two laws of thermodynamics demonstrate energy transfers throughout ecosystems, including food chains, food webs, and trophic levels, at various levels of biological organization. 2. Obtain, evaluate, and communicate information to model the cycling of matter through the biosphere, atmosphere, hydrosphere, and geosphere, including the flow of carbon, water, nitrogen, phosphorus, and sulfur.	**Energy and Matter**
Unity and Diversity		
Biodiversity	3. Construct an explanation of how biotic and abiotic factors affect biodiversity and populations in ecosystems. *Examples: Explain how factors such as biomass, reproductive strategies, succession, climate, and geography affect an organism's chances of surviving and reproducing through successive generations.*	**Cause and Effect**
	a. Support a claim that biodiversity is a natural resource which fosters ecosystem resilience, including the role of keystone, invasive, native, endemic, and indicator species. b. Analyze and interpret data collected through geographic research and field investigations to describe Alabama's biodiversity by region. *Examples: Use relief, topographic, and physiographic maps or information on rivers, forests, and watersheds to investigate species distributions and diversity.*	**Scale, Proportion, and Quantity**

Earth's Systems		
System Interactions	4. Engage in an evidence-based argument to explain how Earth's systems affect the biosphere and the biosphere affects Earth's systems over various amounts of time. *Examples: Use data to make a claim that microbial life increases the formation of soil or that corals create reefs and argue that these processes can alter patterns of erosion and deposition along coastlines.* **Clarification: This discussion should consider Earth's geological history.** 5. Obtain, evaluate, and communicate information regarding how short-term and long-term natural cyclic fluctuations cause ecosystem change. *Examples: Explain how the eruption of volcanoes alters global temperatures or how the El Niño-Southern Oscillation shifts weather patterns. Share information regarding how forest fires can cause deforestation which increases water runoff and soil erosion. Describe how hurricanes destroy dunes and increase coastal flooding.*	**Stability and Change**
Earth and Human Activity		
Natural Resources	6. Obtain, evaluate, and communicate information to describe the use of renewable and nonrenewable energy sources. *Examples: Describe the similarities and differences among fossil fuels. Gather and share information to describe different sources of renewable energy from biomass such as biodiesel, cellulosic ethanol, and algae.*	**Cause and Effect**
	a. Analyze and interpret data on the origins and availability of renewable and nonrenewable forms of energy to predict consumption trends. *Examples: Use a solar irradiance map to predict the best area for a solar thermal power plant. Analyze the distribution of fossil fuel reserves around the globe to identify energy-rich and energy-poor areas and predict future trends in types of fuel used and rates of consumption.*	**Structure and Function**

	b. Construct an argument based on data about the risks and benefits of using renewable and nonrenewable energy sources in Alabama.	**Scale, Proportion, and Quantity**
	7. Obtain, evaluate, and communicate information to describe the development, management, and recycling of mineral resources. *Example: Research technologies used to mine and process rare Earth metals for electronics. Gather information and draw conclusions about the sustainability of plastics recycling.*	**Cause and Effect**
Human Impact	8. Construct or revise a claim based on evidence of the effects of human activities on Earth's systems, natural resources, and ecosystem services. *Examples: Construct a claim that excess nitrogen and phosphorus causes algal blooms, deforestation disrupts carbon storage, or excess atmospheric sulfur leads to acid rain. Construct a claim that changing rain patterns cause flooding or desertification. Construct a claim that temperature cycles affect the timing of migrations and the flowering of plants, causing a disjunction in pollination.* a. Evaluate published information from computational models which illustrate the effects of an increase in atmospheric carbon dioxide on photosynthesis and the effect of ocean acidification on marine populations. b. ⚙Use engineering practices to evaluate and refine a current solution designed to protect natural resources from anthropogenic sources of atmospheric, terrestrial, or aquatic pollution. *Example: Create mechanisms to remove plastic from the ocean or particulates from industrial exhaust.*	

	9. Obtain, evaluate, and communicate information based on evidence to explain how key natural resources, natural hazards, and climate variability influence human activity and welfare. a. Communicate scientific information about how environmental change may disproportionately impact people in certain socioeconomic groups or geographic locations. *Examples: People in lower socioeconomic groups or those who are unhoused are more affected by rising temperatures and heat islands than others. Populations living at lower sea levels are more impacted by sea level rise than those who live at higher elevations. People living in floodplains are more likely to experience seasonal flooding than those living on higher ground.* 10. Use mathematics and graphic models to communicate how human activity may affect genetic variation in organism populations, including threatened and endangered species.	
Human Population and Global Change	11. Construct an explanation of how human populations undergo growth and decline. *Examples: Explain how birth and death rates, infant mortality, nutrition, and other factors increase or decrease human populations.* **Clarification: Use of mathematical calculations to determine growth rate is not required.**	
	a. Analyze and interpret data on human population trends in developing and developed countries and in the global population as a whole. *Example: Use fertility and mortality rates to predict population growth and average population age during different stages of the demographic transition model. Compare age structure diagrams of developing and developed countries to determine differences in population growth rates. Use total fertility rates to predict global population growth rate.*	**Patterns**

	b. Construct explanations of the types of environmental impacts produced by human populations in each stage of the demographic transition model. *Example: Current American quality of life standards from post-industrial development (driving a car, heating and cooling a house) can have a negative impact on the environment. As quality of life, educational opportunities, and gross national product increase, individual resource consumption increases. Transitioning populations may generate increased local solid waste pollution.*	**Scale, Proportion, and Quantity**
	12. Obtain, evaluate, and communicate information to describe the effects of human population growth on global ecosystems. a. Evaluate and communicate information describing the impact of measures used to increase the food supply for the growing human population, including the use of GMOs, monocultures, integrated pest management (IPM), and precision agriculture. b. Evaluate and communicate information describing the effects of urbanization on the environment. *Examples: Creating impervious surfaces such as roads, parking lots, and sidewalks increases flash flooding in low-lying urban areas. Urban sprawl leads to increased use of fossil-fuel-powered transportation and higher levels of local air pollution. An increase in pavement and rooftops and a decrease in green space leads to heat islands.*	**Cause and Effect**
	13. Design and defend a sustainability plan to reduce an individual's ecological footprint, taking into account how market forces and societal demands influence personal choices.	**Scale, Proportion, and Quantity**

Human Anatomy and Physiology

Human Anatomy and Physiology addresses the structure and function of human body systems from the cellular level to the organism level in an approach that complements the natural curiosity of high school students. The standards are designed to help students apply their conceptual understanding of the human body to make well-informed, evidence-based decisions by obtaining and critically evaluating new and changing information from the scientific research community.

Human Anatomy and Physiology incorporates safe laboratory investigations allowing students actively to explore the structure and functions of the human body. Students are encouraged to apply evidence-based reasoning to investigate how organs and systems interact to maintain homeostasis. Hands-on experiences in the lab spark curiosity and build interest in learning how the human body works. Laboratory experiences are especially valuable for students interested in health-related science, technology, engineering, and mathematics (STEM) careers.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through participation in the engineering design process, students will use tools and materials to model a body system.

Although disorders of the human body are not included in the standards, the exploration of disorders can be an extension of learning anatomy and physiology.

Students should use correct scientific and anatomical terminology including directional terms, regions, planes, and cavities when organs and systems are discussed.

Each content standard completes the stem *"**Students will**…"*

From Molecules to Organisms: Structures and Processes		
Tissues	1. Obtain, evaluate, and communicate information to explain how differences in cellular structure (mitochondria, cytoskeletal structure, endoplasmic reticulum, cell membrane) lead to differences in the function and organization of the four tissue types (epithelial, connective, muscular, and nervous).	**Structure and Function**

Integumentary System	2. Obtain, evaluate, and communicate information to describe how the structures of the integumentary system and its accessory organs contribute to its function. *Examples: how the layers of the skin contribute to homeostasis, the role of glands in thermoregulation and in hydration of skin and mucous membranes, the protective functions of hair and nails*	
	a. Construct an explanation of the relationships between the integumentary system and other organ systems, including the body's mechanisms for maintaining homeostasis. *Examples: Explain how changes in vessel diameter and evaporation of water over the skin contribute to thermoregulation (cardiovascular). Explain how sweat is used to excrete nitrogenous waste from the blood (cardiovascular). Explain how the skin and mucous membranes create a barrier against infection (immune system).*	**Stability and Change**
Skeletal System	3. Develop and use a model to illustrate how the structures of the skeletal system contribute to its function. *Examples: Create a diagram or 3D model to illustrate bone shape, joint types, and bones in the appendicular and axial skeletons. Use models to illustrate the role of the skeletal system in movements around joints, support of a body structure, and protection of soft tissues.* a. Obtain, evaluate, and communicate information describing the growth and development of the skeletal system.	**Structure and Function**
	b. Construct an explanation of the relationships between the skeletal system and other organ systems, including the body's mechanisms for maintaining homeostasis. *Examples: Explain the role of spongy bone in hematopoiesis (cardiovascular system) and leukopoiesis (immune system). Explain how the storage of minerals in bone contributes to homeostasis.*	**Stability and Change**

Muscular System	4. Develop and build a three-dimensional model to illustrate the structures of the muscular system, including muscle locations, origins, and insertions, and explain their roles in movement and support. *Example: Design and build a model of a lever to illustrate the relationship between bones and muscles and explain their roles in body movement and support.*	**Structure and Function**
	a. Model the cellular physiology of skeletal muscle, including how the cell functions in muscle contraction and relaxation. *Example: Use straws and paper to create a model of a sarcomere to illustrate how the fibers move during contraction and relaxation.*	**Systems and System Models**
	b. Obtain, evaluate, and communicate information to explain muscle fatigue and tone in terms of muscle cell physiology.	**Structure and Function**
Nervous System	5. Obtain, evaluate, and communicate information explaining the relationship between the structures and functions of the central nervous system and the peripheral nervous system.	
	a. Use a model to illustrate the role of action potentials in neural transmission. **Clarification: Discussions of sodium-potassium pumps and ion channels are not required.**	**Systems and System Models**
	b. Construct an explanation of the role of reflex arcs, the central nervous system, and special senses in the response to stimuli to maintain homeostasis and guide behavior. *Example: smelling a strong odor initiating a sneeze response using a reflex arc; pupil diameter changing in relation to the amount of light entering the eye* **Clarification: Discussion of the anatomy and physiology of the sensory organs is not required.**	**Stability and Change**

	c. Construct an explanation of the role of neurotransmitters in the functions and behavior of the nervous system. **Clarification: Discussion of classes of neurotransmitters is not required.**	**Structure and Function**
	d. Obtain, evaluate, and summarize scientific findings regarding the biological origin of emotions and memories in distinct regions of the brain. *Examples: the role of the frontal lobe in emotional regulation, the regulation of fear response by the amygdala*	
Endocrine System	6. Construct an explanation of how the interdependence of the nervous and endocrine systems maintains homeostasis. a. Obtain, evaluate, and communicate information explaining how hormones secreted by endocrine glands help the body maintain homeostasis through negative and positive feedback loops. *Examples: the role of insulin and glucagon in maintaining glucose levels, the role of parathyroid hormone and calcitonin in maintaining calcium levels* b. Obtain, evaluate, and communicate information describing the role of endocrine axes involving the thyroid and gonads in controlling growth, development, metabolism, and reproduction.	**Stability and Change**
Immune System	7. Obtain, evaluate, and communicate information describing the structure of lymph nodes and primary cells of the immune system (neutrophils, lymphocytes, monocytes, macrophages, eosinophils, and basophils) and explaining their role in inflammation and the body's defense.	**Structure and Function**
	a. Obtain, evaluate, and communicate information explaining how vaccines work to stimulate immunity in the human body.	**Cause and Effect**
	b. Construct an explanation of how the lymphatic system interacts with the immune and circulatory systems.	**Systems and System Models**

Cardiovascular System	8. Obtain, evaluate, and communicate information explaining how the structures of the cardiovascular system are related to its functions.	**Structure and Function**
	a. Create a model to show how a pressure gradient moves blood through the circulatory system. *Example: Apply pressure to water in a closed system to generate circulation.*	**Systems and System Models**
	b. Carry out an investigation exploring the link between blood pressure and heart rate and include the role of baroreceptors and chemoreceptors in the explanation of results.	**Cause and Effect**
	c. Construct an explanation of the cardiovascular system's relationships with other organ systems, including the body's mechanisms for maintaining homeostasis. *Examples: Explain how the nervous system exerts control over cardiovascular function. Explain the role of respiratory gases in cardiovascular function. Explain the filtration of blood to form urine.*	**Stability and Change**
Respiratory System	9. Obtain, evaluate, and communicate information to explain the relationship between the structures and functions of the respiratory system.	**Structure and Function**
	a. Construct an explanation of how the circulatory system works with respiration to transport respiratory gases. b. Use a model to illustrate how pressure gradients move air into and out of the lungs. *Example: Use balloons in a closed system to illustrate the role of negative and positive pressures in airflow in the lungs.*	**Systems and System Models**
	c. Construct an explanation of the respiratory system's relationships with other organ systems, including the body's mechanisms for maintaining homeostasis. *Examples: Explain how the musculo-skeletal system works to move air. Explain that the waste product of cellular digestion (CO_2) is removed by the lungs and controls respiratory rate. Explain the role of the cardiovascular system in the movement of respiratory gases.*	**Stability and Change**

Digestive System	10. Obtain, evaluate, and communicate information explaining the relationship between the structures and functions of the digestive system, including absorption and chemical and mechanical digestion. a. Construct an explanation of the roles of accessory organs (salivary glands, pancreas, and liver) in digestion.	**Structure and Function**
	b. Construct an explanation of the relationships between the digestive system and other organ systems, including the body's mechanisms for maintaining homeostasis. *Examples: Explain how the products of chemical digestion are used in other systems. Explain how waste products from the digestive system are removed by the respiratory and excretory systems. Explain the importance of the immune system in maintaining digestive system health.*	**Stability and Change**
Excretory System	11. Use a model to illustrate the microanatomy of excretory structures and describe their functions. **Clarification: Discussion of microanatomy of the nephron and the steps of urine formation not required.**	**Systems and System Models**
	a. Construct an explanation of how the excretory system maintains homeostasis, including blood pressure and pH. *Example: Explain that urine formation decreases blood volume and can decrease blood pressure.*	**Stability and Change**
Reproductive System	12. Use models to compare and contrast the internal and external structures of the female and male reproductive systems and their production of gametes. **Clarification: Meiosis, fertilization, and embryonic development do not need to be included in this discussion.**	**Systems and System Models**
	a. Construct an explanation of how the endocrine system influences the growth, development, and functions of the reproductive systems in males and females, including the mechanisms of hormonal birth control.	**Cause and Effect**

Physical Science

Physical Science is a conceptual, inquiry-based course that investigates the basic concepts of chemistry and physics, including energy, waves, electricity and magnetism, atomic structure, nuclear chemistry, matter, and solutions. This course is designed to prepare students for further studies in chemistry and physics by building upon content knowledge, including chemical bonding and reactions and Newton's laws of motion, from Grade 8 Physical Science. In this course, students use evidence from their own investigations and the work of others to develop and refine knowledge of the disciplinary core ideas. They apply mathematical and language skills to create increasingly more sophisticated model-based explanations and arguments. The standards promote a depth of conceptual understanding and scientific literacy that will adequately prepare students for college, career, and citizenship. Various resources, including those specific to the local area and evidence-based literature found within scientific publications, should be used to extend and increase the complexity of the core ideas.

Content standards are organized according to the disciplinary core ideas for the physical science domain. The first core idea, "Matter and Its Interactions," deals with the substances and processes of the universe on microscopic and macroscopic levels. The second one, "Energy," involves conserving energy, energy transformations, and energy applications to everyday life. The third core idea, "Waves and Their Applications in Technologies for Information Transfer," examines wave properties, electromagnetic radiation, information technologies, and instrumentation.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon⚙. Through participation in the engineering design process, students use data to justify the selection of a particular material for a specific application and evaluate the effects of using ions or isotopes of elements as a solution to a complex real-world problem.

Although not included as discrete standards, these scientific practices should be embedded throughout the courses:

- Measurement - Choose appropriate tools and record measurements with the correct number of significant figures to show measured and estimated digits and units.
- Dimensional analysis - Perform unit conversions using dimensional analysis.
- Scientific notation - Use scientific notation to report very large or small quantities with the correct number of significant figures and carry out multiplication, division, addition, and subtraction calculations with scientific notation.
- Graphing - Create graphs to determine and communicate relationships between variables, and analyze graphs to make predictions about unknown data points.

Each content standard completes the stem *“**Students will**…”*

<table>
<tr><th colspan="3">Energy</th></tr>
<tr><td rowspan="3">Energy</td><td>1. Evaluate sources of information concerning the law of conservation of energy to illustrate energy transformations in practical applications and natural systems.
Examples: Describe energy transformation when an arrow is fired from a bow. Illustrate how solar energy is transformed into chemical energy and then into mechanical energy which living things use to do work.
a. Plan and carry out investigations to explore how mechanical energy is transformed within a system, including kinetic energy, gravitational potential energy, elastic potential energy, and work.
Examples: Using a digital simulation of a skateboarder moving through a loop, construct energy bar charts and use mathematical expressions to represent the energy changes.</td><td>Systems and System Models</td></tr>
<tr><td>b. Collect, analyze, and use data to explain how thermal energy is transferred by conduction, convection, and radiation.
c. Construct explanations to justify the selection of materials for specific applications based on the materials’ specific heat values.
Examples: Engineers choose to use ethylene glycol in coolants because of its high specific heat.</td><td>Energy and Matter</td></tr>
<tr><td>d. Investigate collisions and other real-world situations to evaluate the effects of impulse on changes in momentum.
Examples: Explain how an airbag increases the contact time during a collision and therefore reduces the force experienced by a crash test dummy.</td><td>Cause and Effect</td></tr>
</table>

Waves and Their Applications in Technologies for Information Transfer		
Properties of Waves	2. Obtain, evaluate, and communicate information to compare and contrast the properties of mechanical and electromagnetic waves as they relate to real-world applications. *Examples: Compare and contrast the transfer of electromagnetic radiation from the sun to Earth with the motion of mechanical waves created by an earthquake.* a. Analyze and interpret data to identify and describe the relationships among wavelength, frequency, amplitude, and energy in waves.	**Energy and Matter**
	b. Develop models to illustrate reflection, refraction, interference, and diffraction. c. Analyze the ways in which different media and their characteristics affect the speed of sound and light waves. d. Use models to illustrate the Doppler effect and explain the changes in sound perception associated with it.	**Cause and Effect**
	e. Obtain and communicate information from published materials to explain how transmitting and receiving devices use the principles of wave behavior and wave interactions to transmit and capture information and energy. *Example: Research and explain how cell phones utilize electromagnetic and mechanical waves.*	**Systems and System Models**
Electricity and Magnetism	3. Construct an explanation of the ways in which modern science uses both magnetic and electric concepts to create usable products. *Examples: induction cooktops, stereo speakers, electric motors, wireless chargers*	**Energy and Matter**
	a. Construct an argument using evidence to support the claim that field forces exist between objects and act on the objects even when the objects are not in contact. *Examples: magnetism, gravity, electrical charge*	**Systems and System Models**
	b. Plan and carry out investigations to identify the factors that affect the strength of the electric and magnetic forces between objects.	**Cause and Effect**

	c. Use mathematics and computational thinking to represent and determine the quantitative relationships between voltage, current, and resistance in series and parallel circuits in terms of Ohm's law. d. Develop and use models to determine the relationships among voltage, current, and resistance at specific loads in series and parallel circuits.	**Systems and System Models**
	e. Plan and carry out investigations to determine the relationships between magnetism and electrical charge in common devices. *Examples: electromagnets, generators, electric motors*	**Cause and Effect**
	f. Analyze and interpret data concerning the advantages and disadvantages of the energy sources used to produce electricity. *Examples: wind, solar, radioactive elements, fossil fuels, hydroelectric*	**Energy and Matter**
	Matter and Its Interactions	
Structure, Properties, and Nuclear Processes	4. Evaluate the effects of using ions or isotopes of elements as a solution to a complex real-world problem, including cost, safety, trade-offs, and environmental impacts. *Examples: Assess the environmental benefits and impacts associated with the production, usage, and disposal of lithium ion batteries.*	**Stability and Change**
	a. Obtain, evaluate, and communicate information from the periodic table concerning the structure of an atom and the arrangement of the atom's protons, neutrons, and electrons.	**Patterns**
	b. Predict the properties of an element based on the element's number of protons and valence electrons. c. Analyze and interpret data to predict properties of ionic and covalent compounds. d. Use mathematics and computational thinking to determine the charge of an ion and the mass number of an isotope based on the number of subatomic particles.	**Structure and Function**

	e. Analyze and interpret data to explain how radioactive decay changes a radioactive isotope over time and explain how the age of an object can be estimated by the ratio of radioactive isotopes contained within the object's atoms. f. Use mathematics and computational thinking to identify types of radioactive decay based on balanced chemical equations, penetrating power, identity of emitted particles, and charge.	**Cause and Effect**
	g. Use models to explain how nuclear fission and fusion reactions can be used as energy sources.	**Energy and Matter**
	h. Generate and defend a data-based claim regarding the use of radioactive materials as an energy source.	**Systems and System Models**
Matter	5. Analyze and interpret data to justify the selection of a specific material for a practical application, considering a range of constraints. *Examples: Investigate multiple physical and chemical properties to generate and defend a claim about why engineers choose specific materials in the design of cookware.* a. Carry out investigations and use results to compare and contrast the physical and chemical properties of matter. *Examples: density, hardness, conductivity, magnetism; flammability, reactivity*	**Cause and Effect**
	b. Analyze and interpret data to predict changes in the phase of a material based on changes in particle motion, temperature, pressure, or thermal energy. *Examples: Utilize phase change diagrams to predict state of matter at a given temperature and thermal energy. Analyze a triple point graph to predict the state of matter at a given temperature and pressure.*	**Patterns**

	c. Use mathematical and computational thinking to determine the quantitative relationships among temperature, pressure, and volume of confined gases. d. Utilize multiple types of models to support and verify the claim that matter is conserved during a simple chemical reaction. *Examples: particle diagrams, chemical equations, physical manipulatives, chemical reaction investigation*	**Energy and Matter**
Solutions	6. Obtain, evaluate, and communicate information to explain how the properties of various types of solutions make them useful in real-world applications. *Examples: Make a claim from research to defend why certain alloys are chosen in the production of specific parts of musical instruments (e.g. brass instruments, guitar strings, and metallophones). Explain the selection of citric acid in the flavoring in juices and sodas.*	
	a. Plan and carry out investigations to determine how various factors, including temperature, surface area, and stirring, affect the rate at which a solute dissolves in a solvent. b. Develop and use particle diagrams to illustrate diluted and concentrated solutions and describe how adjusting amounts of solute and solvent impacts the concentration of a solution.	**Cause and Effect**
	c. Analyze and interpret data from experiments to determine whether solutions are acidic, basic, or neutral to predict properties of the solutions. *Example: Given the hydronium ion concentration of a solution, predict the color of the solution if phenolphthalein was added. Classify a solution based on the color change of pH paper.*	**Energy and Matter**
	d. Plan and carry out investigations concerning neutralization reactions and describe the properties of the reactants and products. *Example:* $HCl + NaOH \rightarrow NaCl + H_2O$*; acidic and basic reactants form salts and water*	**Cause and Effect**

Physics

Physics is a physical science course that provides high school students with foundational content regarding the properties of physical matter, physical quantities, and their interactions. The course provides the required science background preparation for students pursuing postsecondary studies and careers in science, technology, engineering, and mathematics (STEM) fields.

In Physics, students learn through investigation, experimentation, and analysis of data. The academic language of physics is used in context to communicate claims, evidence, and reasoning for phenomena and to engage in arguments from evidence to justify and defend claims. Students take part in active learning involving authentic investigations and engineering design processes. The course provides a rich learning context for acquiring knowledge of the practices, core ideas, and crosscutting concepts that develop scientific literacy and critical thinking, problem-solving, and information literacy skills. External resources, including evidence-based literature in scientific journals, research, and other sources, should be utilized to provide students with science experiences that will adequately prepare them for college, career, and citizenship.

Content standards within this course are organized according to three of the disciplinary core ideas for physical science. The first core idea, "Motion and Stability: Forces and Interactions," concentrates on forces and motion, types of interactions, and stability and instability in physical systems. The second core idea, "Energy," investigates energy conservation, transformations, and applications to everyday life. The final core idea, "Waves and Their Applications in Technologies for Information Transfer," examines wave properties, electromagnetic radiation, information technologies, and instrumentation.

Embedded in the content standards are the disciplinary core ideas of the Engineering, Technology, and Applications of Science (ETS) domain, which require students to use design strategies in conjunction with knowledge and understanding of science and technology to solve practical problems. Engineering standards are denoted with a gear icon. Through participation in the engineering design process, students design solutions to determine the magnitude and direction of the buoyant force acting on an object and the force's effects on the object's motion.

This course is designed to provide students with a deep exploration of kinematics, dynamics, and conservation, while also surveying circular motion, waves, fluids, and electricity.

Although not included as discrete standards, these scientific practices should be embedded throughout the course:

- Measurement - Choose appropriate measurement tools and record measurements with the correct number of significant figures to show measured and estimated digits and units.
- Significant figures - Record the correct number of significant figures after performing mathematical calculations with the data.
- Dimensional analysis - Perform unit conversions using dimensional analysis, including conversions of derived units such as km/hr; N/m^2, kg/m^3.

- Scientific notation - Use scientific notation to report very large or small quantities with the correct number of significant figures and carry out multiplication, division, addition, and subtraction calculations with scientific notation.
- Graphing - Create graphs to determine and communicate relationships between variables, and analyze graphs to make predictions about unknown data points.

Each content standard completes the stem *"**Students will**…"*

<table>
<tr><th colspan="3">Motion and Stability: Forces and Interactions</th></tr>
<tr><td rowspan="4">Kinematics</td><td>1. Obtain, evaluate, and communicate ideas about kinematics, including scalar quantities (distance and speed) and vector quantities (position, displacement, velocity, and acceleration).</td><td>Scale, Proportion, and Quantity</td></tr>
<tr><td>a. Analyze data to create and interpret graphs of position, velocity, and acceleration versus time for one-dimensional motion.</td><td>Patterns</td></tr>
<tr><td>b. Analyze free fall motion using one-dimensional kinematics to determine the acceleration due to gravity (g).
c. Analyze and interpret data to explain changes in the vector quantities of position, velocity, and acceleration in two-dimensional projectile motion, including projectiles launched horizontally and at an angle.</td><td>Cause and Effect</td></tr>
<tr><td>d. Use mathematics and computational thinking to solve problems, using kinematics equations in both one- and two-dimensional motion.</td><td>Patterns</td></tr>
<tr><td>Dynamics</td><td>2. Construct explanations of dynamics from evidence, using Newton's laws of motion.
a. Evaluate the effects of balanced and unbalanced forces on an object's motion.
b. Use mathematical, graphical, and narrative methods to explain the relationships among net force, mass, and acceleration of a single object.</td><td>Cause and Effect</td></tr>
</table>

	c. Create free and fixed body diagrams to model all the forces acting on a single object. d. Create an explanation of the nature of forces and the interactions among them, including tension, friction, gravitation, and normal forces, using free-body diagrams.	**Systems and System Models**
	e. Analyze data to identify the pair of equal and opposite forces between two interacting bodies and relate their magnitudes and directions using Newton's third law.	**Cause and Effect**
Energy		
Conservation	3. Design and carry out experiments to verify that energy and momentum are conserved in closed systems.	**Energy and Matter**
	a. Use mathematical and computational thinking to explain the relationships among work, power, and time.	**Scale, Proportion, and Quantity**
	b. Create mathematical and graphical representations to depict the transformation of energy from one form to another, including kinetic energy, gravitational potential energy, elastic potential energy, and work due to friction. c. Use models to illustrate the relationship between the work performed on an object and the object's total mechanical energy. *Example: energy bar chart*	**Energy and Matter**
	d. Qualitatively and quantitatively evaluate the relationship among the force acting on an object, the time of interaction, and the change in linear momentum (impulse) of the object.	**Scale, Proportion, and Quantity**
	e. Obtain, evaluate, and interpret data related to collisions (both elastic and inelastic) and their effects on both linear momentum and energy conservation.	**Cause and Effect**

Motion and Stability: Forces and Interactions		
Fluids	4. Use mathematics and computational thinking to analyze the effects of pressure changes and buoyant forces in fluid systems.	**Cause and Effect**
	a. Plan and carry out experiments to determine the density of objects. b. Use and solve algebraic formulas to determine the relationships between pressure, force, area, and density. *Examples: P=F/A; P=ρgh*	**Scale, Proportion, and Quantity**
	c. ✿Design solutions to determine the magnitude and direction of the buoyant force acting on an object and the effects of the buoyant forces on the object's motion.	**Systems and System Models**
	d. Use the buoyant force acting on an object and free body diagrams to determine the acceleration of submerged objects.	**Scale, Proportion, and Quantity**
Circular Motion	5. Develop and use models to analyze the circular motion of objects.	**Systems and System Models**
	a. Use mathematics and free-body diagrams to relate the tangential velocity, the radius of orbit, the centripetal acceleration, and force to each other for an object moving in a circle.	**Scale, Proportion, and Quantity**
	b. Develop and use a model to describe the mathematical relationship between mass, distance, and force as expressed by Newton's law of universal gravitation.	**Systems and System Models**

Energy		
Electricity	6. Obtain, evaluate, and communicate information concerning static and current electricity.	**Scale, Proportion, and Quantity**
	a. Develop and use a model to describe the mathematical relationship among charge, distance, and force as expressed by Coulomb's law.	**Systems and System Models**
	b. Obtain, evaluate, and communicate information regarding the relationship among voltage, current, and power for direct current circuits.	**Scale, Proportion, and Quantity**
	c. Create models of series, parallel, and mixed direct current circuits.	**Systems and System Models**
	d. Use mathematics and computational thinking to determine the voltage, current, and resistance for an entire circuit and at each resistor or load. *Examples: use measurement devices and Ohm's law*	**Scale, Proportion, and Quantity**
Waves and Their Applications in Technologies for Information Transfer		
Waves	7. Obtain, evaluate, and communicate information regarding the propagation, properties, and applications of waves. a. Use mathematics and computational thinking to describe the relationships among the velocity, frequency, and wavelength of a propagating wave.	**Scale, Proportion, and Quantity**

	b. Use results of investigations to explain the production and characteristics of sound waves including interferences, the Doppler effect, and standing waves. *Examples: the relationship between amplitude and wave energy, the relationship between frequency and pitch*	**Energy and Matter**
	c. Obtain, evaluate, and communicate information to explain the properties and behavior of electromagnetic waves.	

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